NOV 20 1928

Vol. 20, No. 3 October, 1928

Medical Lib.

PARASITOLOGY

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CAMBRIDGE UNIVERSITY PRESS

LONDON: FETTER LANE, E.C. 4

ALSO

H. K. LEWIS AND CO., LTD., 136, GOWER STREET, LONDON, W.C. 1

WHELDON AND WESLEY, LTD., 2–4, ARTHUR STREET, NEW OXFORD STREET, LONDON, W.C. 2

CHICAGO: THE UNIVERSITY OF CHICAGO PRESS
(AGENT FOR THE UNITED STATES)

BOMBAY, CALCUTTA, MADRAS: MACMILLAN & CO., LTD.

TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

Fifteen Shillings net

[*Issued* 31 *October* 1928]

PRINTED IN GREAT BRITAIN

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VOLUME XX OCTOBER, 1928 No. 3

A SURVEY OF HUMAN INTESTINAL PROTOZOA IN SWEDEN AND FINLAND.

(A PRELIMINARY REPORT.)

BY RUTH M. SVENSSON, *Med. lic.* (UPSALA).

Hospitalet, Lund, Sweden.

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I. INTRODUCTION.

LITTLE attention has hitherto been paid in the Scandinavian countries to human intestinal protozoa, with the exception of *Balantidium coli* which has been encountered and reported not infrequently. Motile flagellates have also been observed occasionally in diarrhoeic stools, and a few cases of amoebic dysentery, acquired abroad, have been treated in home hospitals. However, the impulse to investigate intestinal protozoa, created by the possible danger of amoebic dysentery being introduced by troops invalided from war zones, did not reach the Scandinavian countries, as these never entered the War. As work of recent years has proved that intestinal protozoal infections, previously assumed to be more or less restricted to the tropics and subtropics, occur indigenously also in temperate regions such as Britain, France, Holland, Germany, North America, and North China, it has seemed to the writer a matter of great interest to ascertain whether countries as far north as Sweden and Finland would offer suitable conditions for the spread and maintenance of such infections. A previous survey of human intestinal protozoa in China, conducted in collaboration with Dr John F. Kessel (Kessel and Svensson, 1924), gave me opportunities of becoming familiar with most of the intestinal protozoa of man.

The present survey was commenced in October 1925 and has been continued at intervals till March 1928. It includes 2014 persons, all of them patients in hospitals for physical and mental diseases in Sweden and Finland. Without the cordial co-operation of the medical and nursing staffs in the hospitals investigated, the work could not have been done. I am especially

indebted to Prof. Ulrik Quensel, head of the Pathological Institution of Upsala, for procuring the funds necessary for undertaking the survey and for his never-failing interest and helpful suggestions during the progress of my work. To Prof. Germund Wirgin, head of the Bacteriological Institution in Upsala, I am indebted for furnishing me with laboratory equipment at the beginning of the survey. Mr Clifford Dobell, F.R.S., has most generously helped me in preparing this paper for publication and has given me useful suggestions and information concerning preparations and questions of special interest or doubt, for which I wish to express to him my most sincere gratitude. I have also been fortunate to have his library at my disposal as well as his advice concerning literature.

II. Plan of the Survey.

After a tentative survey of 177 patients in the Academic Hospital of Upsala had revealed the presence of all the common protozoa, the further part of the work was planned to elucidate some special questions, mainly of hygienic and sanitary importance. In order to ascertain whether Public Health measures such as a good water and sewage system and strict control of the food-handling are able to diminish faecal contamination as indicated by the frequency of protozoal infection, 196 hospital patients, resident in Stockholm, were compared with 235 hospital patients from other parts of Sweden, mostly rural. In order to obtain information concerning the influence of institutional life upon the distribution of intestinal protozoa, 1244 patients in three mental asylums were examined. Certain food habits of the population in Finland have, as demonstrated by Ehrström (1925) and others, resulted in a helminthic fauna differing from the findings in Sweden. It was therefore considered a matter of interest to compare the intestinal protozoa of these two countries, and 159 patients visiting the medical out-patients department of the University of Helsingfors were included in the survey.

III. Material and Methods.

The faecal samples for examination were taken from stools passed spontaneously or after administration of a water enema. The microscopic examination was made as soon as possible, often within a couple of hours after the stool had been voided. A preliminary examination was made in normal saline and Donaldson's iodine-eosin solution. Although an accurate diagnosis of the protozoa encountered was usually possible with this method alone, permanent preparations were made from the positive cases by fixing films in Schaudinn's solution and staining them with Heidenhain's iron-alum-haematoxylin. The stained preparations were then examined with a 1/12″ oil-immersion lens for a closer study of morphological details.

The time available for this survey having been limited, as a rule only one examination has been made of each case. Where a protozoon has to be excluded or incriminated as the cause of a disease, it is necessary to examine six

samples or more from each case before a person can be declared with any certainty to be free from infection, as first pointed out by Dobell (1917) and later confirmed by other authors. The aim of this survey, however, has not been to make a clinical diagnosis of individual cases or to elucidate the pathogenicity of intestinal protozoa, but to investigate the influence of certain living conditions among different groups of people, using the protozoal infection as an index. I believe that more valuable information can be gained by an extensive study of as many cases as possible in each group of people (keeping in mind that the actual incidence of infection will probably be approximately two to three times as high as that discovered by one examination) than by an intensive study of a small number of cases each examined six or more times. Although I am aware, therefore, that my figures do not give exact information regarding the incidence of protozoal infection in Sweden and Finland, I believe them to be representative and comparable for the different series in the survey. In comparisons between the different groups, only the findings for the first examination of each case are recorded, while in the summary all the protozoa met with during the work are included.

IV. SURVEY OF RESULTS.

The examination of faecal specimens from 2014 cases revealed the presence of the following protozoa:

AMOEBAE.	*Entamoeba histolytica*	in 140 cases
	Entamoeba coli	„ 618 „
	Endolimax nana	„ 368 „
	Iodamoeba bütschlii	„ 131 „
	Dientamoeba fragilis	„ 16 „
FLAGELLATA.	*Giardia intestinalis*	„ 92 „
	Chilomastix mesnili	„ 267 „
	Trichomonas hominis	„ 10 „
	Small flagellates[1]	„ 14 „
CILIATA.	*Balantidium coli*	„ 3 „

In the stools passed spontaneously or after administration of a water enema, *Dientamoeba fragilis* was detected only five times, *Trichomonas hominis* twice, and a small flagellate and *Balantidium coli* once each. As the majority of my cases passed formed stools and the species of protozoa just mentioned are not likely to be found unless the stools are loose or liquid, another examination was made of 46 persons in a heavily infected group of people (mental asylum cases), after purging with $MgSO_4$. The results are recorded in Table I.

[1] I have not been able to identify the species of these small, very actively motile flagellates in the saline preparations, and they are extremely difficult to stain. Cysts of *Enteromonas hominis* have been observed, but not recognized during the survey, and records have not been kept of them. After having been shown these cysts by Mr Dobell, I have been able to identify them from my own preparations. Whether the small motile flagellates have all been *Enteromonas hominis*, or some of them *Embadomonas intestinalis*, I am not able to decide.

Table I.

Percentages of infections found in formed and loose stools.

Number of cases: 46

Character of Stool	Formed	Loose or liquid
Protozoa found:		
Entamoeba histolytica	32·6	30·4
E. coli	50·0	54·4
Endolimax nana	41·3	54·4
Iodamoeba bütschlii	32·6	30·4
Dientamoeba fragilis[1]	8·7	23·9
Giardia intestinalis	8·7	8·7
Chilomastix mesnili	28·3	32·6
Trichomonas hominis	—	17·4
Small flagellates	—	30·4
Balantidium coli	—	4·3

As indicated in this table, the chances of infections being detected in formed and loose stools were about equal for *Entamoeba histolytica*, *E. coli*, *Iodamoeba bütschlii*, *Giardia intestinalis*, and *Chilomastix mesnili*, whereas *Endolimax nana* had a slightly better chance of discovery in the stools obtained by purging. As a rule, however, the protozoa occurred much more abundantly in the loose stools and mostly as conspicuous motile forms; while the formed stools contained only cysts, often in small numbers and easily overlooked unless searched for very carefully. This applies especially to *Chilomastix*, which was always very abundant in the loose stools, whereas sometimes only one or two cysts could be found in a whole preparation of the formed sample. A striking difference is shown with *Dientamoeba fragilis*, *Trichomonas hominis*, *Balantidium coli*, and the small flagellates, which occurred very rarely or not at all in the formed stools, whereas the loose specimens contained them quite frequently. My findings are in good agreement with the often-made observation of diarrhoeic stools containing large numbers of motile flagellates. None of my purged cases suffered from any intestinal disorder, except a certain degree of constipation, and my findings support the view expressed by Dobell (1917) concerning *Trichomonas* that "it is probably nearer the truth to say that diarrhoea is a 'cause' of a detected infection with *Trichomonas* than that infection with *Trichomonas* is a 'cause' of diarrhoea."

The findings in the three groups of people, (1) hospital patients in Sweden, (2) asylum patients in Sweden, and (3) out-patients in Helsingfors, Finland, are recorded in Table II.

The two groups of people with physical diseases show a conspicuous difference, Finland showing throughout a considerably higher percentage of infection with all the common species of protozoa. Whether this indicates a real difference in incidence of protozoal infection between the populations of the two countries in general, I am not sure. The group from Finland is considerably smaller than the Swedish group. It includes people from only one region,

[1] Four cases with previously diagnosed infection with *Dientamoeba fragilis* were included in this group, the remaining 42 cases were chosen at random.

Table II.

Cases examined...	611 hospital cases Sweden		1244 asylum cases Sweden		159 out-patients Finland	
Protozoa found:	Number	%	Number	%	Number	%
Entamoeba histolytica	9	1·5	117	9·4	14	8·8
E. coli	71	11·6	501	40·3	46	28·9
Endolimax nana	54	8·8	287	23·1	27	17·0
Iodamoeba bütschlii	8	1·3	113	9·1	10	6·3
Giardia intestinalis	31	5·1	51	4·1	10	6·3
Chilomastix mesnili	6	0·9	255	20·5	6	3·8

Helsingfors and its environs, while the hospital cases in Sweden came from three different areas. But even considering these facts, it seems probable that protozoal infection is more common in Finland than in Sweden.

Another difference, more striking and indisputable, is that existing between the series of hospital cases and asylum cases in Sweden. With the exception of *Giardia*, every species displays an incidence 3–20 times higher in the asylum group than in the hospital group. Especially noteworthy is the high percentage (20·5 per cent.) of *Chilomastix* among the mental cases. A similarly high incidence of *Chilomastix* in mental asylums has been observed by Matthews and Smith (1919) in England (23·2 per cent.); while Thomas and Baumgartner (1925) and Boeck and Stiles (1923), in U.S.A., give the percentages of 21 and 16·3 respectively. All these authors report a very high incidence also of the other species, except *Giardia*.

V. Discussion of Special Results.

As this paper is only a part of a work still in progress, and further results and their bearing on questions of hygiene and sanitation will be dealt with later, no exhaustive discussion is attempted here. Only a few observations of more general interest will be recorded.

Stockholm and Rural Districts. The assumption that Public Health measures, such as a good water supply and sewage system and a strict control of the food-handling, such as exist in Stockholm, offer a certain protection against the risk of intestinal infections, appears to be supported by my findings, as tabulated below.

Residents in...	Stockholm		Rural districts	
Number of cases...	192		235	
Protozoa found:	Number	%	Number	%
Entamoeba histolytica	3	1·6	4	1·7
E. coli	18	9·4	36	15·3
Endolimax nana	15	7·7	29	12·3
Iodamoeba bütschlii	3	1·6	5	2·1
Giardia intestinalis	7	3·6	16	6·8
Chilomastix mesnili	1	0·5	3	1·3

It is my intention to extend the investigations of these two groups of people, as the number of cases is as yet too small to allow absolute conclusions

to be drawn. They strongly suggest, though, that there is a lower degree of infection with protozoa among the residents of Stockholm than among people living in rural districts. This is not surprising, if we consider certain factors in the life-conditions of peasants and farmers in Sweden which are likely to facilitate the distribution of protozoal cysts. Human faeces are used as manure in fields and gardens. Latrines are often situated near dwellings, and they are not protected from flies. Houses are not usually screened, and flies are often abundant in kitchens and living rooms. Houseflies therefore have good opportunities to play the part in distribution of protozoal cysts which they are able to do, as proved by the experiments of Wenyon and O'Connor (1917). As to personal hygiene and cleanliness, there is probably very little difference between people belonging to the two groups discussed here.

Asylum group. The high incidence of protozoal infection in mental asylums does not seem to be correlated with any special form of mental disease. One determining factor seems to be the length of time spent in the institution. One hundred cases examined during the first month, mostly within a few days of admission, show an incidence of infection even lower than the group with physical ailments. The rise in the percentages of infections is directly proportional to the length of time in the institution up to ten years, as shown in Table III. After ten years of confinement no additional increase of infections seems to occur.

Table III.

	Mental asylum cases						
Time in the institution...	< 1 month	1–12 months	1–2 years	2–5 years	5–10 years	> 10 years	Hospital cases
Number of cases...	100	159	129	248	197	368	611
Percentage of infection with:							
Entamoeba histolytica	1	7·5	3·9	12·1	10·7	12·8	1·5
E. coli	5	26·4	38·8	41·9	47·2	49·5	11·6
Endolimax nana	5	17·0	16·2	25·8	28·9	24·4	8·8
Iodamoeba bütschlii	0	4·4	4·7	11·3	12·2	12·0	1·3
Giardia intestinalis	3	5·7	5·4	4·9	4·1	3·5	5·1
Chilomastix mesnili	4	9·4	13·2	22·6	27·9	26·1	0·9

A noticeable feature in this table is that the incidence of *Giardia* seems to remain practically the same throughout the whole time of institutional life, whereas the other species show an incidence of infection 5–13 times as high for the cases of long confinement as for those newly admitted. In the surveys of asylum cases in England and America already mentioned, no higher percentages of *Giardia* infection are reported than for the general populations of these countries, although all the other infections are much higher for the asylum groups. Even allowing for the fact that *Giardia* is more sporadic in its occurrence in the stools of an infected person than are the cysts of other protozoa, as has been proved by Dobell (1917), the number of all asylum cases reported and invariably showing a low *Giardia* incidence is sufficiently large to eliminate any error due to a disproportionate prevalence of *Giardia* cases

in which the infection is difficult to detect. It can hardly be assumed that the exposure to *Giardia* infection would be slighter than the exposure to other species. It therefore seems more probable that the low *Giardia* incidence indicates a lower susceptibility to infection with this protozoon, possibly due to increasing age.

Table IV.

	Men		Women		Total	
	Number	%	Number	%	Number	%
Cases examined...	515		729		1244	
Protozoa found:						
Entamoeba histolytica	76	14·7	41	5·6	117	9·4
E. coli	248	48·2	253	34·7	501	40·3
Endolimax nana	169	32·8	118	16·2	287	23·1
Iodamoeba bütschlii	86	16·7	27	3·7	113	9·1
Giardia intestinalis	35	6·8	16	2·2	51	4·1
Chilomastix mesnili	136	26·4	119	16·3	255	20·5

Table IV shows that there is a significant difference between the infections of men and women in the asylums. This concerns all species of protozoa, but it is especially evident with *Entamoeba histolytica* and *Iodamoeba bütschlii*, the former being 2·6, the latter 4·5 times as common in the men as in the women. This difference cannot be assumed to be the result of a higher degree of susceptibility to infection in men than in women, as my group of hospital cases, including 313 men and 298 women, shows an equal percentage of infection (22·7 and 22·5 per cent. respectively). The higher incidence of infections among the male patients is probably due to the fact that patients are employed on work in the wards, for distribution of the food and washing up of dishes. The women, being trained for this kind of work, are likely to do it more skilfully and with less risk of spreading infections. As an illustration of this possibility, I may note that in one men's ward with cleanly and sober patients, mostly newly admitted, a very high percentage of infections was found, although all the other wards with a similar type of patients invariably showed a low incidence of infections. The patient serving as a kitchen hand in the heavily infected ward, however, was proved to be the host of eight different species of protozoa, and had probably handed out his own protozoa with the food to his co-patients. No conspicuous lack of personal cleanliness had been observed in this patient.

Many of the asylum patients, especially the chronic cases, cannot, even with strict supervision, be kept to clean and hygienic habits. This alone might account for the high incidence of infection. In the light of some recent experiments another suggestion might, however, be ventured. Practically all of my hospital cases passed formed stools, and a large proportion of them suffered from constipation, presumably due to lack of exercise, and in some cases to administration of opium. As shown by Sellards and Theiler (1924) and Boeck and Drbohlav (1925) kittens will more readily be infected with cysts of *Entamoeba histolytica* if intestinal stasis is produced. Is it not possible that the

intestinal stasis present in many asylum patients may increase their susceptibility to infection, and so account for the high incidence of infection observed in them?

Regarding the asylum cases, it may also be noted that in spite of their protozoal infections they were, with a few exceptions, enjoying good physical health.

VI. Some Observations on the Different Species of Protozoa.

The protozoa found in Finland will not be dealt with here. Investigation has, I believe, been commenced at the medical clinic of Helsingfors and will eventually gather observations which will elucidate more adequately than my small series the protozoon question in Finland.

Entamoeba histolytica. Among 611 hospital patients in Sweden nine (or 1·5 per cent.) were found to be harbouring *E. histolytica.* Five infections were found among 265 patients with pulmonary tuberculosis, while the remaining four were detected in a group of 346 general hospital cases in medical wards. None of these gave a history of dysentery or even persistent diarrhoea more than can be extracted from the past history of almost any case if carefully probed. The patients came from several different parts of Central and South Sweden and had been, at the time of examination, admitted to four different hospitals. In each hospital at least two cases were found, which indicates that *E. histolytica*, although scarce in its occurrence, is evenly spread over the parts of Sweden mentioned above. Among 1244 patients in three mental asylums in the same parts of Sweden, 117 were found to harbour *E. histolytica*, which gives an incidence of 9·4 per cent., or more than six times as high as the hospital group.

Some predisposing factors in the spread of intestinal infections in asylums have already been mentioned above. The patients harbouring *E. histolytica* did not seem to be inferior in general health to those who did not reveal the presence of such infection. But as there is no way of knowing, from one single examination, how many cases were really uninfected, very little importance can be attached to a comparison between groups of positive and "negative" findings. Some cases suffering from chronic diarrhoea were examined more frequently, and had six examinations or more each, but in none of them was *E. histolytica* found.

The cysts have not actually been measured, but two races have been observed to occur commonly, mostly singly, but sometimes simultaneously in the same case. One of the races is estimated to be a little larger than a red blood corpuscle and it often contains numerous chromatoid bodies of irregular shape. The other race is well over 10 μ in diameter, the chromatoid bodies, when present, are mostly few in number and typically rod-shaped with rounded ends. Some of the big cysts with exceptionally thick walls show in stained preparations a peculiar arrangement of the nuclear chromatin, practically all of it being concentrated in what looks like a big and somewhat dispersed karyosome,

while very little chromatin is to be seen on the nuclear membrane. This type of nucleus answers to the description given of *Councilmania lafleuri* by Kofoid and Swezy (1921). As shown by Wight and Prince (1927) for *Entamoeba coli*, this nuclear picture is an artifact due to the use of hot Schaudinn's solution, which has been the method used by me. The majority of *E. histolytica* cysts, however, show the nuclear structure described by Dobell and O'Connor (1921).

Entamoeba coli. In Sweden, as everywhere else where protozoological surveys have been undertaken, *E. coli* has been found to be the commonest of all intestinal protozoa in man. In the hospital group 11·6 per cent. and in the asylum group 40·3 per cent. of infection was detected by one examination.

In the fixed and stained preparations typical cysts of *E. coli* were found with nuclear membranes rich in chromatin and small, eccentric, compact karyosomes. Cysts answering to the descriptions of *Councilmania lafleuri* were also found: and budding forms with chromophile ridges and nuclei with central, dispersed karyosomes. These features, however, are not always combined in the same cyst. A cyst with a chromophile ridge, or even a bud, might show a nuclear structure typical of *E. coli*. Moreover, if a faecal sample which in stained preparations shows a large number of budding cysts, is examined in normal saline, no budding forms can be found. Only twice have I seen in fresh smears what might be taken for a bud, although thousands of such pictures have been observed in stained specimens. Cases passing 8-nucleate cysts have been purged in order to obtain motile amoebae and in two such cases I have observed the clear hyaline pseudopodia supposed to be typical of *Councilmania*, although the stained preparations have contained cysts of *E. coli* type alone. These observations led me to doubt the distinction between *E. coli* and *Councilmania lafleuri*. After reading the papers by Wight (1925) and Wight and Prince (1927), which describe exactly the same observations and demonstrate how budding forms and chromophile ridges can be produced at will, not only of *E. coli*, but of *Entamoeba histolytica* and *Iodamoeba bütschlii* as well, I have been convinced of the identity of *E. coli* and *Councilmania lafleuri*.

Endolimax nana, next to *Entamoeba coli*, is the commonest of intestinal protozoa found in Sweden, the hospital group showing an incidence of 8·8 per cent. and the asylum group 23·1 per cent. by one examination. In one case numerous "budding" forms were found in the stained preparations. Otherwise this protozoon in my findings conforms in every way to the descriptions given by Dobell (1919). Filamentar inclusions as pictured by him (Pl. II, fig. 28) have been observed by me, but still more pronounced, the nuclei being quite entangled in long coiling filaments. Individuals parasitized by *Sphaerita* have also been encountered.

Iodamoeba bütschlii seems to be a fairly rare parasite among the population of Sweden, as far as this is represented by the group of hospital patients. Only 1·3 per cent. of them were found to be infected (see Table II). Moreover, it

seems to be more sporadic in its occurrence than the other species of protozoa. For instance, among 177 patients in the Academic Hospital of Upsala it was not met with in one single case. The mental asylums show a distribution of infections that might be called endemic, not only in a particular institution, but even in certain wards. In one asylum *I. bütschlii* was found in 29·2 per cent. of the 72 patients in a men's ward; in another asylum, in a men's ward with 25 patients, seven or 28 per cent. were found infected. In all three institutions the men were much more heavily infected than the women, showing 16·7 per cent. of infection as compared with the 3·7 per cent. average incidence among the women. In the hospital patients group the infections were about equal among men and women.

Dientamoeba fragilis. My findings seem to indicate that this protozoon, although rarely recorded, is more common than has been supposed. It has been found in four different series of my survey, which shows that it is widely spread in this country. Not more than 16 cases are recorded, but 15 of these occurred in a group of only 46 persons, four of which, though, were known previously to harbour the organism. Nevertheless, not counting these, *Dientamoeba* was present in 11 out of 42 arbitrarily chosen cases. The method of demonstrating the amoebae was to examine the loose stools, still warm, which had been obtained after administration of 30–40 gm. of $MgSO_4$. If fixed without delay, good preparations can be made of the protozoa from samples obtained by this method. There seems little reason to doubt that if more cases are treated in the same way, *Dientamoeba* will continue to show its presence in a high percentage of cases in Sweden, and very likely in other countries.

Morphologically the *Dientamoeba* found in Sweden does not differ from the first description of it given in the original paper by Jepps and Dobell (1918)[1]. No cysts have been found in my cases.

Giardia intestinalis. Excepting the low percentage of infections with this protozoon found in mental asylums and already briefly discussed, nothing especially noteworthy has been observed regarding *Giardia.* It was found in 5·1 per cent. of the hospital cases in Sweden and in 4·1 per cent. of the asylum cases.

Chilomastix mesnili. Only 0·9 per cent. of the hospital cases were found infected with this flagellate, while the mental asylum cases showed the surprisingly high percentage of 20·5. It was very prevalent in all the three institutions investigated, although a certain difference prevailed, two of the institutions showing a percentage of 24·8 and 20·1 respectively, while the third one showed an incidence of 12·6 per cent. In the latter institution a comparatively large number of newly admitted cases were examined, which tended to lower the percentage. The reason why *Chilomastix* should be so conspicuously prevalent in mental asylums is not easy to find. Even the cases in Finland, which for the other species of protozoa show percentages of infections not much lower

[1] Mr Clifford Dobell kindly examined a preparation of *Dientamoeba fragilis* which I sent to him and confirmed my diagnosis of this protozoon.

than the Swedish asylum cases, show an incidence of *Chilomastix* 5·4 times lower than the insane in Sweden.

Trichomonas hominis. As is well known, this flagellate does not occur in formed stools, and as most of the samples examined by me belonged to this category, it is not surprising that it was not encountered more than twice in the spontaneously passed stools. Its occurrence eight times in the loose and liquid stools of 46 arbitrarily chosen cases indicates, however, that it is fairly common among inhabitants of Sweden. The same applies to the small flagellates found 14 times in the same group.

Balantidium coli. This ciliate has attracted a considerable amount of attention in Sweden and Finland since its discovery by Malmsten in Stockholm in 1857. In my final paper I shall attempt to summarize the records relating to this parasite. In the present survey it has been encountered three times, once in Finland and twice in asylum patients in Sweden after purging with $MgSO_4$. One of these cases I had the opportunity of following for some time. The ciliates could be demonstrated in every loose or liquid stool after purging, though they were never present in discoverable numbers in the formed stools. This agrees with Brug's observation (1926) on a case of *B. coli* infection at Weltevreden (Java). The Balantidia, he reports, were present in every diarrhoeic stool and could be brought out by laxatives, but they were not demonstrable in formed stools. The other Swedish case, which was examined only once, showed cysts in small numbers as well as motile forms. In the two cysts observed, the cilia were still seen in slow movement inside the cyst-wall. In perusing the literature on *B. coli*, I can find very few records of cysts found in human cases. Walker (1913) states that he tried to infect monkeys with encysted Balantidia from man, and Ohi (1924) describes the morphology of cysts of Balantidium which he states were found in a human infection. In Finland, where about 30 human cases of infection with *B. coli* are met with every year, a cyst has never yet been reported (*fide* Prof. Robert Ehrström).

No intestinal disturbances were present in my three cases at the time of examination. The two asylum patients in Sweden were too far advanced in their mental disease to be able to give any information regarding their past history.

VII. SUMMARY.

This survey records the intestinal protozoa found in 611 hospital cases in Sweden, 1244 mental asylum cases in Sweden, and 159 medical out-patients in Finland. Only one examination was made of each case.

In each of these three groups the following protozoa were found: *Entamoeba histolytica*, *E. coli*, *Endolimax nana*, *Iodamoeba bütschlii*, *Giardia intestinalis*, and *Chilomastix mesnili*. In hospital and asylum cases in Sweden *Dientamoeba fragilis* was encountered, *Trichomonas hominis* and a small flagellate were found in the asylum group, and in this group as well as in the series in Finland, *Balantidium coli* was met with. In one case cysts of this protozoon were found.

In a group of 46 cases, formed stools as well as loose stools obtained after administration of a purgative were examined. The loose samples revealed the presence of *Trichomonas hominis*, *Balantidium coli*, and a small flagellate, none of these having been found in the formed specimens. The percentage of *Dientamoeba fragilis* rose from 8·7 per cent. in the formed stools to 23·9 per cent. in the loose stools. All the other species were more abundantly present in the loose than in the formed samples.

In Sweden, mental asylum cases show a much higher incidence of infections than do the hospital cases.

Intestinal protozoa seem to be more common in Finland than in Sweden.

Among hospital cases in Sweden the residents of Stockholm show a lower incidence of infections than do the people living in rural districts.

At admission, asylum cases are not infected to a higher degree than are the general hospital cases. The rise in incidence of infection is directly proportional to the length of time spent in the institutions up to ten years, after which time no further increase occurs. The male patients show throughout considerably higher percentages of infections than the female patients. *Chilomastix mesnili* shows a very high incidence in the asylums, whereas the percentage of *Giardia intestinalis* remains practically the same throughout the time of confinement in the institution.

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(*MS. received for publication* 15. v. 1928.—Ed.)

BILHARZIA INFECTION IN SOUTH AFRICA.

By F. G. CAWSTON, M.D. (Cantab.).

Durban, Natal.

(With a Map.)

In 1916 Dr J. C. Becker[1] made the interesting discovery of Bilharzia infection in *Physopsis africana* collected at Nijlstroom in the Transvaal and obtained the adult flukes in some guinea-pigs he had exposed to infection with the cercariae. The town of Nijlstroom is situated at the source of a tributary of the Limpopo river at an altitude of 3924 feet above the Indian Ocean into which it flows. In 1917 I collected[2] infested examples of *P. africana* at Magaliesburg, a popular picnic place for Krugersdorp residents, situated on a branch of the Little Crocodile river which later joins the Limpopo. Magaliesburg has an altitude of 5000 feet above sea-level. I also obtained infested examples from Rustenburg, thus revealing a further source of infection from tributaries of the Little Crocodile river, at an altitude of over 4000 feet.

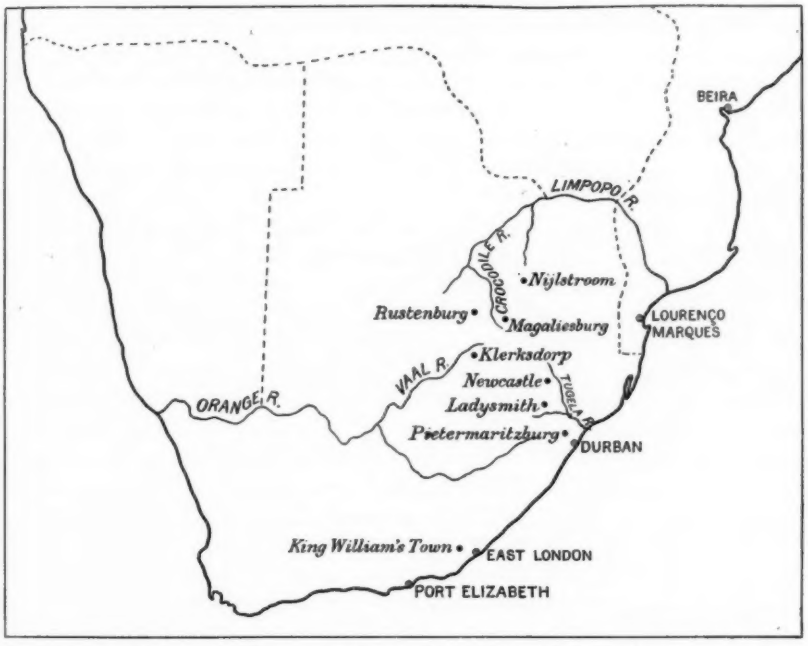
In December of 1917 I obtained infested *Physopsis* at Klerksdorp, on a tributary of the Vaal which joins the Orange river before emptying into the South Atlantic on the West Coast. Klerksdorp has an altitude of 4300 feet and, although *P. africana* has not yet been reported from localities west of this, it should be possible to collect specimens along the course of these rivers below Klerksdorp. Under the auspices of the Streatfield Research Committee in 1921, I obtained[3] *P. africana* infested with *Schistosomum haematobium* at Port Elizabeth in the Cape Province, which is the most southerly point at which the infection has been found. At one time the disease was common at King William's Town, 1275 feet above sea-level; it occurs in various parts of Pondoland.

Bilharzia disease is rare in the highlands of Natal; but I have treated a few cases of the disease acquired locally at New Hanover at an altitude of about 2600 feet, and at Hatting-spruit at an altitude of about 4300 feet. Hatting-spruit is situated on the course of the Ingagane river which joins the Buffalo and empties into the Tugela on its way to the Indian Ocean. Bilharzia disease would not seem to exist around Ladysmith or along the course of the Tugela river until it is joined by the Buffalo.

[1] Becker, J. C. (IV. 1916). *Med. J. of S. Africa*, **11**, No. 9.
[2] Cawston, F. G. (IX. 1917). *Med. J. of S. Africa*, **13**, No. 2.
[3] Cawston, F. G. (1923). *Trans. Royal Soc. S. Africa*, **11**, pt. 2.

No cases of the disease have been reported from the Newcastle area, at an altitude of nearly 3900 feet; though I have collected examples of *P. africana* from a pool along the course of the Incandu river there, and the Ingagane river flowing through Hatting-spruit at an altitude of 4300 feet passes about 25 miles from the township.

The favourite foods of *Physopsis africana*, *Nymphaea stellata* and *Cyperus immensus* C. B. Clarke, are less common, if they occur at all, at these high altitudes. They grow principally in coastal areas in subtropical districts, which may help to explain the fact that Bilharzia disease occurs more in subtropical areas than in the tropics themselves.



Map of South Africa showing places referred to in the text. The elevation in feet above sea-level is as follows for certain places: King William's Town, 1275 ft.—Klerksdorp, 4300 ft.—Ladysmith, 3300 ft.—Magaliesburg, 5000 ft.—Newcastle, 3900 ft.—Nijlstroom, 3924 ft.—Pietermaritzburg, 2200 ft.—Rustenburg, 4000 ft.

Though Bilharzia disease is occasionally encountered at higher altitudes in Rhodesia, it is prevalent at Umtali, at an altitude of 3650 feet, where one of my patients contracted the infection. The port of Beira derives much of its vegetable and fruit supply from the Umtali district. A. Bettencourt and I. Borges[1] have drawn attention to a few cases of Bilharzia disease which they have observed at various altitudes above sea-level in Portugal. The average tempera-

[1] Bettencourt, A. et Borges, I. (13. IV. 1927). *Bull. Soc. Pathol. Exot.* **20**, No. 4.

ture of these infected districts would appear to be slightly less than that of the South African infected areas; it is only exceptionally that frost and snow occur where *Physopsis* is to be found. The disease in Egypt, which these authors describe as "patrie par excellence de la bilharziose," is also most common at low altitudes.

The shells of the ova of *Schistosomum haematobium* obtained from the urine of Portuguese patients would appear to vary within the same limits as are observed in other parts of the world. In Natal, however, one sometimes encounters the eggs of other schistosomes associated with those of *S. haematobium*, and adult species of *S. bovis* have been reared from cercariae obtained from *Physopsis*, whilst *S. spindalis* has been successfully reared in the Transvaal and would seem to occur as a rare parasite of man in Natal.

In South Africa, although Bilharzia disease is contracted from certain well-known pools along the course of infected rivers, the principal source of infection are the pools which are used for paddling, bathing and fishing by indigent persons at brickfields and, in such pools, the usual methods of water-purification to render water free from Bilharzia infection should be applied vigorously from time to time.

The natural pools of water or vleis are generally free from Bilharzia infection, and I do not know of any in which *Physopsis* is to be found; though *Bulinus tropica*, whose variable shell has sometimes resulted in its being called by several different names, such as *schakoi*, *natalensis*, *craveni* and *sericina*, is generally to be found attached to the water-weeds and a fair proportion of the specimens are usually infested with amphistome cercariae.

These vleis are used for watering cattle and much dung occurs in the marshy land around the water; the trematodes of cattle have thus every facility of completing their life-cycle, but few of these collections of water are used for bathing. On the other hand, where a dam-wall is erected along the course of a South African river, one frequently comes across examples of *Physopsis africana* attached to the wall or breeding on the broad leaves of water vegetation and on floating wood; so that these pools are particularly likely to constitute a focus of Bilharzia infection in the neighbourhood where lads use them for swimming. The occasional heavy rains help to clean out infection from these artificial collections of water and to wash the mature snails down to the sea; unless they happen to be washed into overflow pools where they breed with ease, particularly if, as is common, these pools contain the common broad rush *Cyperus immensus* C. B. Clarke or the blue lotus plant. Every endeavour should be made to destroy examples of *Physopsis* which so readily become infested with the Bilharzia parasites. Examples of *Planorbis pfeifferi* are also better destroyed; other species are too seldom infested with the human parasites to justify a wholesale destruction in South Africa.

I would never countenance the wholesale destruction of *Limnaea natalensis* Krauss, except in those limited areas where fluke infestation of cattle and sheep is prevalent. Fresh-water snails serve as a valuable food-supply for

wild birds, whilst assisting fresh-water fish in keeping semi-stagnant water clean and sweet.

The crushed root of *Tephrosia*, the common kind of wild pea which the South African natives use to poison the fish they wish to catch for eating, is very lethal (if undried or boiled) to *Physopsis africana*, because this species of fresh-water snail does not crawl out of the water so often as do some other species. It is perhaps one hundred times as useful as copper sulphate as a means ready to hand for destroying the Bilharzia snail-host in South Africa; for one part in 25 millions is said to destroy fish within an hour, without being poisonous to man or cattle. Whilst deprecating the use of either of these poisons in the wholesale destruction of molluscan life in rivers, further use might well be made of the crushed root of *Tephrosia* in those small collections of water, frequented by boys for fishing and bathing, in order to discourage fishing in such infected pools and to obviate the danger of contracting Bilharzia disease from the water.

Conclusions.

Although examples of *Physopsis africana* Krauss have been collected in the Transvaal at an altitude of 5000 feet above sea-level and Bilharzia disease is encountered at this altitude amongst those who bathe in the streams, the disease is comparatively rare in Natal above Pietermaritzburg, which is situated only 2200 feet above sea-level.

The heavy infestation of the Rustenburg district corresponds with the breeding of *Physopsis africana* in this district and the numerous examples of *Planorbis pfeifferi* which may be collected in this locality, which is about 4050 feet above sea-level on a tributaryof the Little Crocodile river. The infected localities, which are situated at high altitudes, constitute an ever-present source of danger to persons making use of river-water lower down-stream.

In view of the ease with which examples of *Physopsis* take up infection and continue to spread that infection, every effort should be undertaken to destroy this fresh-water snail. *Planorbis pfeifferi* Krauss is likewise better destroyed. Other fresh-water snails, in view of their general uses, should not share in a wholesale destruction of possible Bilharzia carriers; though, in districts known to be infested with the liver fluke parasites of cattle and sheep, every effort should be made to destroy infested examples of *Limnaea natalensis* Krauss.

Natural collections of water of South African vleis (swamps) are usually entirely free from Bilharzia infection; though influences to favour the life-cycle of cattle parasites abound. Bilharzia infection is incurred through bathing in stagnant pools along the course of certain rivers where *Physopsis africana* Krauss breeds with ease and more particularly whilst fishing in pools on brick-fields. In such collections of water, the crushed root of *Tephrosia* promises to be of far greater practical use in the destruction of *Physopsis* than other means at our disposal.

(*MS. received for publication* 8. v. 1928.—Ed.)

THE STRUCTURE OF THE HEAD AND MOUTH-PARTS IN THE NYCTERIBIIDAE (DIPTERA PUPIPARA).

By B. JOBLING.

(*From the Wellcome Bureau of Scientific Research, London.*)

(With Plates XIV–XVI and 4 Text-figures.)

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Introduction.

The present study of the head of the Nycteribiidae was commenced immediately after the publication of my paper on the structure of the head and mouth-parts of the Hippoboscidae, but lack of material prevented me from completing the work until Dr Hugh Scott, of the Cambridge Museum, very kindly provided me with additional material, and I take this opportunity of expressing my thanks to him. I am also indebted to Major E. E. Austen, of the British Museum (Natural History Department), for two specimens of *Cyclopodia sykesi* Westw.

The anatomy of the head of the Nycteribiidae has not been much studied. There is a very short description of this part of the body in Speiser's paper (1901) and in the paper written by Massonnat (1909). A study of this kind appears to be not without interest, since it may throw some light on the phylogeny of the family, which together with the Hippoboscidae and the Streblidae belongs to the polyphyletic group Pupipara. I refrain, however, from the discussion of the phylogeny of the flies in question until the other family, Streblidae, has been studied and more information collected concerning the structure of the head of the Cyclorrhapha-Acalyptratae.

THE HEAD CAPSULE (Text-figs. 1 and 2).

The head capsule of *Cyclopodia sykesi* Westw. is funnel-shaped and compressed dorso-ventrally. In *C. greeffi* Karsch. the shape of the head is essentially the same as in the former species, whereas in *C. roylei* Westw. it is strongly arched dorsally in its anterior part and has nearly the same form as that found in *Nycteribia*. The dorsal surface of the head represents the vertex (*v.*), which extends from the membranous ptilinum (*pt.*) to the thickened border of the occipital foramen (*o.f.*). In the Nycteribiidae the structure of the vertex is uniform; it is not subdivided, as in the Hippoboscidae and the Streblidae, into several subregions which differ anatomically one from another. In *C. sykesi* three-fourths of this region bear setae directed forwards; moreover, very strong setae are present on the anterior border of the vertex. These are arranged in two groups, each group consisting of five setae of which the middle one is twice as long as the others. As regards the chaetotaxy of the vertex in *C. greeffi* and *C. roylei*, it must be pointed out that in the former species there are present only two long setae on the anterior border of the vertex, which are apparently homologous with the longest setae of *C. sykesi*, whereas in *C. roylei* there are six short setae between the long ones.

Anteriorly the vertex is separated by the ptilinum from the fronto-clypeus and by the eyes from the genae; laterally it is continuous with the postgenae (*pg.*) and there is no suture separating these regions of the head.

The ventral surface of the head capsule is almost entirely occupied by the postgenae since, through the great modification of the posterior part of the head, the occiput is represented by the thickened border of the occipital foramen only. The postgenae are separated from each other by the median membranous region of the head, like those of the Hippoboscidae. They have very smooth surfaces and bear very strong setae arising from their inner borders. Anteriorly each postgena is continuous with the gena (*g.*), which occupies the antero-lateral part of the head capsule immediately in front of and below the eye. The gena is rounded anteriorly and has two closely approximated rows of setae along its antero-dorsal border. The parts of the gena and the postgena which adjoin the eye are membranous.

The eye of *C. sykesi* is composed of two cylindrical ocelli; these undoubtedly represent the greatly modified lenses of the compound eye of the other Diptera. Each ocellus arises from the chitinous ring attached to the outer surface of the head capsule. The rings are the external parts of the darkly pigmented and cup-shaped internal structures of the eye (Text-fig. 2); these structures are fused together and have one common opening at the posterior end, through which the ocular nerve passes, giving a branch to each ocellus. If we compare the structure of the eye of *C. sykesi* with that of the most specialised Hippoboscidae it becomes obvious that the above described internal structure of the former fly is the greatly modified ocular sclerite (*oc.s.*). The structure of the eye of *C. greeffi* is similar to that of *C. sykesi*. In *C. roylei* each eye has two ocelli,

but the ocular sclerite has undergone much greater reduction and is less darkly pigmented than in the two former species. The eyes of *Eucampsipodia hyrtli* Kol. have no ocular sclerite, each of them being represented by a semispherical

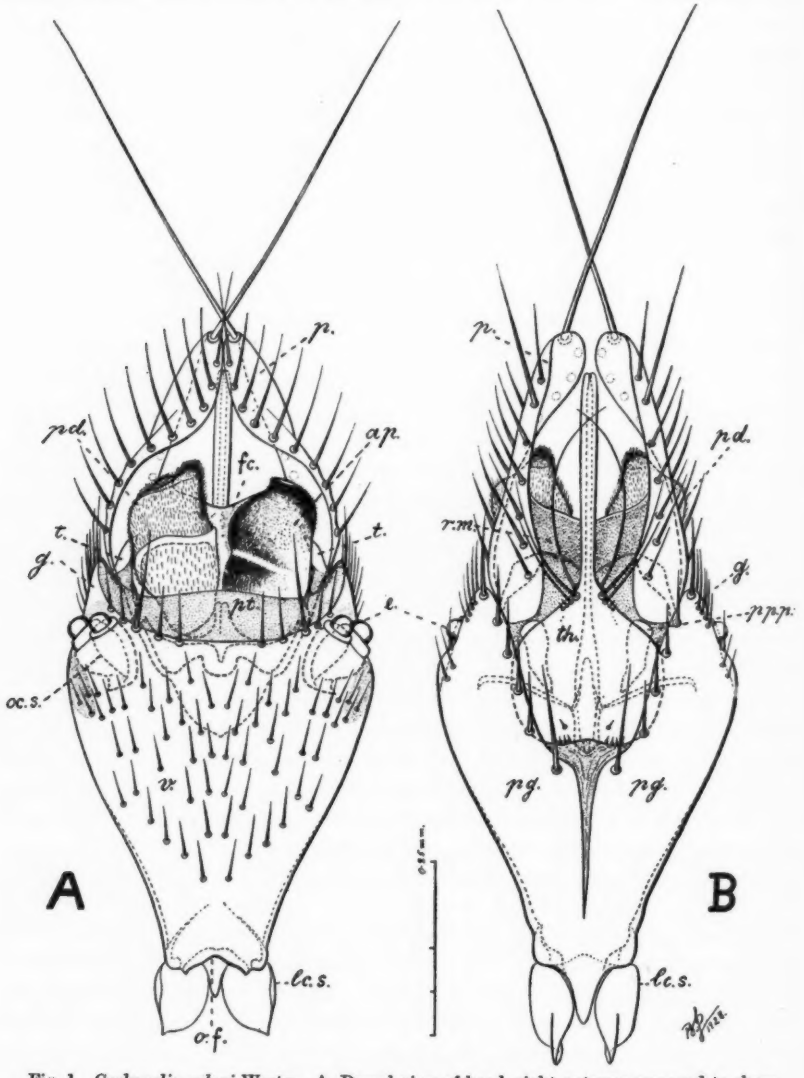

Fig. 1. *Cyclopodia sykesi* Westw. A, Dorsal view of head, right antenna removed to show antennal pits; B, Ventral view of same.

ocellus situated in the shallow depression of the latero-anterior part of the head capsule. In *Penicillidia jenynsi* Westw. the eyes have the same structure as in *E. hyrtli*, though they are not situated in the depressions.

As regards the structure and position of the fronto-clypeus, it must be noted that in the Muscidae and the generalised Hippoboscidae this structure is separated by the ptilinum from the vertex and only partly from the genae, while in the most specialised Hippoboscidae the ptilinum extends towards the ventral surface of the head and is connected with the membrane of that surface, separating the fronto-clypeus completely from the head capsule. The latter condition of the fronto-clypeus, but in a more marked degree, is present in the Nycteribiidae, in which it is separated by the membrane from the postgenae and by the ptilinum from the vertex and the genae.

Text-figs. 1 A and 2 show that the fronto-clypeus of *Cyclopodia sykesi* occupies the most anterior part of the head capsule, extending obliquely and anteriorly from the vertex. Its posterior border (Text-fig. 3 B) bends dorsally in the middle, and there is a flattened process (*pr. fc.*) which projects into the head capsule immediately below the ptilinum and the anterior border of the vertex. The anterior border of the fronto-clypeus has two flap-like projections which are covered with very minute bristles and curved upwards towards the

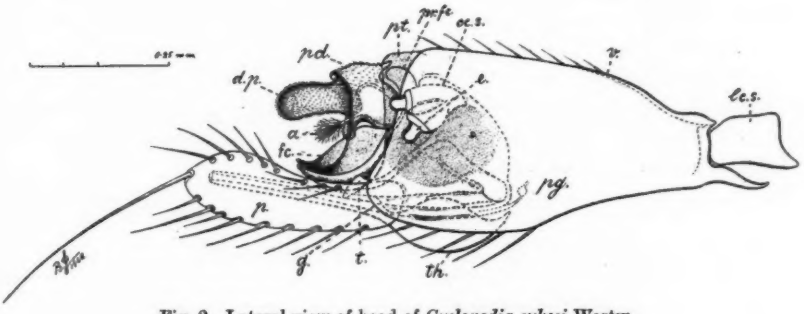

Fig. 2. Lateral view of head of *Cyclopodia sykesi* Westw.

head. Immediately behind each projecting part the fronto-clypeus is depressed; this depression is the anterior antennal pit (*a.p.*) in which the arista of the flagellum is concealed. The pits are darkly pigmented and are separated by the median convexity of the fronto-clypeus from each other. Behind the anterior pits there are present two posterior ones which occupy the posterior half of the fronto-clypeus; in these lies the rounded ventral part of the pedicle of the antennae.

The ptilinum of *Cyclopodia sykesi* is not retracted inside the head capsule, as in those Diptera which have this organ. Text-figs. 1 A and 2 show that the ptilinum overlaps the antennae dorsally and extends between the latero-posterior parts of the fronto-clypeus and the genae ventrally. It is attached to the vertex and the genae posteriorly and to the fronto-clypeus anteriorly. Its membrane is thin and bears very minute flat, rounded scales in the posterior part of the upper surface. Being weakly chitinised and lightly pigmented, these scales are very difficult to detect in the cleared preparation of the head. In

Penicillidia jenynsi Westw. I was unable to investigate the ptilinum, since in this species the frontal part of the vertex is densely covered with very stout and darkly pigmented setae, which obscure the view of the anterior border of this region of the head. In *Eucampsipodia hyrtli* Kol. and in *Nycteribia biarticulata* Dufour, the structure of the ptilinum is the same as in *Cyclopodia sykesi*, whereas in *Nycteribia parvula* Speiser the ptilinum does not project over the antennae frontally, its membrane extending along the middle of the anterior part of the vertex and being deflated inside the head capsule to form a shallow median groove, which is broad at the anterior border of the vertex and gradually diminishes in width towards its posterior end.

Rodhain and Bequaert (1916) indicate that before the appearance of the adult of *Cyclopodia greeffi* Karsch. the pupa is detached from the object to which it is fixed and the fly emerges through the thin membrane of the ventral surface of the pupal case. From this description it appears that the ptilinum does not play any part during the emergence of the adult insect. According to Muir (1912), who studied the pupa of *Penicillidia progressa*, "The position of the head of the pupa would prevent the use of the ptilinum, as the legs are folded over the head and thorax, the femoratibia joints meeting in the middle line. A movement of the legs would force off the operculum."

To the description of the ptilinum given above it is necessary to add that this organ is apparently not adapted to break the anterior end of the puparium. It is modified into the flexible joint connecting the motile fronto-clypeus with the immovable parts of the head capsule.

The Antennae (Text-fig. 3).

It was noted by Massonnat (1909) that the antennae of the Nycteribiidae have very much in common with those of the Hippoboscidae which parasitise birds. I have shown elsewhere (1926) that all the parts of the hippoboscid antennae are homologous with those of the muscid, the modifications in the hippoboscid type having arisen in consequence of the adaptation of these flies to a parasitic mode of life and serving to protect the most important parts of the organs from the feathers or hairs of the host which the fly encounters during progression.

The antenna of the Nycteribiidae appears to consist of one segment, but on critical examination it is found to be composed of two segments which are homologous with the second and third segments of the antenna of the Hippoboscidae. The scape, which is the first antennal segment in all the Diptera except some of the Hippoboscidae, is absent in the antennae of the Nycteribiidae, therefore the first segment of their antenna is the pedicle (*pd.*).

The pedicle of *Cyclopodia sykesi*, as well as of all the other genera of this family which have been studied, is similar in structure to that of the Hippoboscidae parasitising birds. It is composed of two distinct parts, posterior and anterior. The former is darkly pigmented and bears very small spines on its dorsal surface. The ventral portion of this part is rounded and has an ovoid

cavity in which the second segment of the antenna, the flagellum, is concealed. The anterior part of the pedicle represents the so-called dorsal prolongation (*d.p.*) which, together with the dorsal surface of the posterior part of this segment, is only seen in the total preparation of the head capsule. The dorsal prolongation arises from the frontal surface of the posterior part and extends slightly beyond the anterior border of the fronto-clypeus (Text-fig. 1 A). Its dorsal surface is convex and densely covered with spines, whereas the ventral surface is deeply concave and overlaps the anterior antennal pit dorsally. The pedicle is provided with a ganglion, which is connected with the antennal nerve through the opening in its posterior part, and in its antero-dorsal border is inserted the *elevator of the pedicle* (*e.pd.*) arising from the posterior part of the

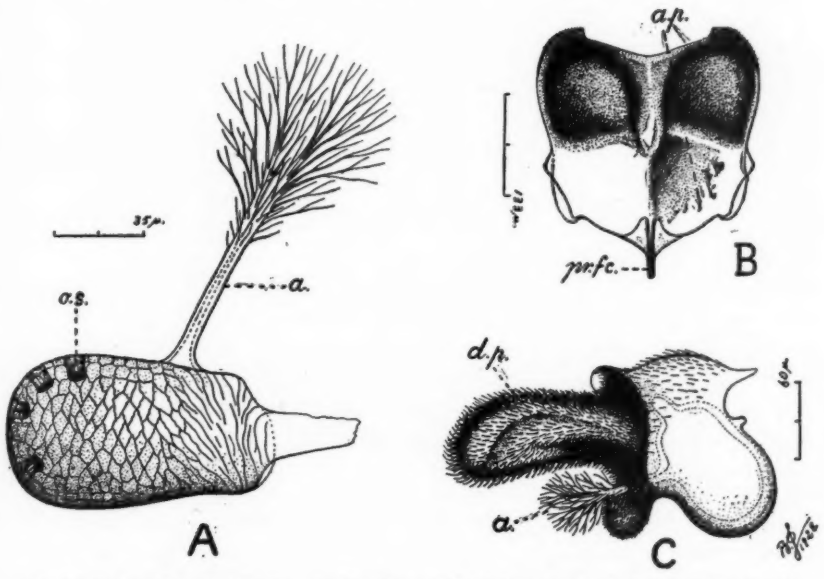

Fig. 3. *Cyclopodia sykesi* Westw. A, Flagellum with arista (*a.*) and olfactory sensillae (*o.s.*); B, fronto-clypeus; C, pedicle, dotted lines indicate position of flagellum.

fronto-clypeus. When the pedicle is depressed the anterior border of the dorsal prolongation becomes interlocked with the flap-like part of the fronto-clypeus, enclosing the arista (*a.*) completely in the cavity formed by the anterior antennal pit and the concave ventral surface of the dorsal prolongation.

The second segment of the antenna, or the flagellum, is pyriform; from its postero-dorsal surface arises the arista, which projects through the opening of the pedicle under the posterior part of the dorsal prolongation. There are present four olfactory pits in the anterior part of the flagellum, from the bottom of each of which arises the sensilla. The surface of the flagellum is reticulose, except the posterior part, which gives off a conical process serving for the

attachment of this segment to the pedicle. The conical process has an opening through which the sensory cells of the flagellum are connected with the ganglion of the pedicle (Pl. XIV, fig. 1).

The Mouth-parts. General Account (Text-fig. 4).

The mouth-parts and the chitinous structures, which though morphologically belonging to the head are closely connected with them, compose what is universally called the proboscis. In the Nycteribiidae this consists of the same parts as in the Hippoboscidae and the relation of the parts to each other is practically alike in both families. The proboscis is divided into three regions, viz. the *rostrum*, the *haustellum* and the *labella*. The rostrum is composed of the following parts: the rostrum membrane (*r.m.*), the maxillary palps (*p.*), the post-palpal plates (*pp.p.*), the stipites (*s.*), the hyoid (*hy.*), the anterior portion

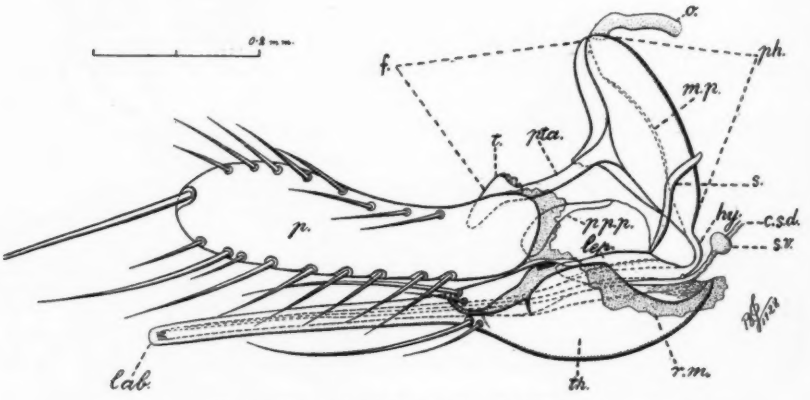

Fig. 4. Proboscis of *Cyclopodia sykesi* Westw.

of the salivary duct and the salivary valves (*s.v.*) and the fulcrum (*f.*). The last named is formed by the fusion of the tormae (*t.*), paratormae (*pta.*) and the pharynx (*ph.*). All these parts except the maxillary palps and the stipites belong morphologically to the head; moreover, the maxillary palps are the only structures which lie completely outside the head capsule, being attached to the rostrum membrane posteriorly. The haustellum includes the labrum-epipharynx (*lep.*), the hypopharynx (*h.*) and the major part of the labium. The latter is composed of two parts—an external or the theca (*th.*) and an internal or the labial gutter (*l.g.*). The hypopharynx is completely enclosed in the labial gutter, as well as the lateral and the ventral parts of the labrum-epipharynx. The labella (*lab.*) are represented by the membranous distal parts of the proboscis. Morphologically these structures belong to the labium, since they have originated from the greatly modified two-segmented labial palp.

THE ROSTRUM (Text-figs. 1, 2, 3; Pls. XIV and XV).

The *rostrum membrane* (*r.m.*) exhibits a fibrous structure in the stained preparations; its outer surface is densely covered with very small, basally flattened spines, directed anteriorly. The membrane arises from the anterior border of the fronto-clypeus dorsally, from the genae and the postgenae laterally, and is continuous posteriorly with the median membranous part of the head capsule as in the Hippoboscidae. The anterior part of the rostrum membrane is attached to the posterior border of the bulbous part of the theca and to the labrum (Pl. XV, fig. 5). When the proboscis is protracted the membrane is completely everted, forming the membranous cone on the ventral side of the head and exposing the bulbous part of the haustellum exactly in the same way as in many Hippoboscidae (Pl. XIV, fig. 1). The latter position of the membrane and the haustellum has been observed in spirit specimens of species of *Cyclopodia* and *Nycteribia*. The protraction of the proboscis apparently occurred during the death of the insect. It is quite probable that this condition resembles the position of the proboscis of an insect in feeding, since the same phenomenon has been observed many times during fixation of the Hippoboscidae, in which the position of the protracted proboscis was the same as in the feeding insect.

The *maxillary palps* (*p.*) of the Nycteribiidae, as of the Hippoboscidae, consist each of a single joint. In *Cyclopodia sykesi* they are bent in the middle and have both surfaces chitinised. The outer surface of the palps is convex and very thick, whereas the inner is concave and thin. They bear very strong setae along the dorsal and ventral borders of their outer surfaces and each have the terminal seta which is half as long again as the palp. In *Penicillidia jenynsi* the setae of the outer surface of the palp are more numerous and differ very much in length, the most anterior seta being nearly three times as long as the palp, whereas the terminal one is about four times as long. *Eucampsipodia hyrtli*, *Nycteribia biarticulata* and *N. parvula* have the palps much narrower than the genus *Cyclopodia*; they closely resemble those of the genus *Penicillidia*, though the setae on their outer surfaces are not so numerous. The palps are attached by their posterior end to the rostrum membrane between the tormae and the genae. They are supported by the post-palpal plates (*pp.p.*), which represent the secondary structures originated through the chitinisation of the parts of the rostrum membrane. In the Nycteribiidae the palps have no muscles of their own, but are brought into motion by the muscles of the rostrum, as in the Hippoboscidae.

The *stipites* (*s.*) of the Nycteribiidae are very similar in structure to those of the Hippoboscidae and their position is the same in both families. In *Cyclopodia sykesi* they represent the curved rods of which the anterior ends are movably attached to the slightly projecting lateral parts of the posterior border of the labrum; they are also connected with the antero-dorsal part of the rostrum membrane, as in the Hippoboscidae (Pl. XIV, fig. 2). The posterior

ends of the stipites are not attached to the other chitinous structures of the head; they serve for the insertion of the muscles of the rostrum.

The *fulcrum* (*f.*). It has already been shown that this part is composed of two tormae (*t.*) which are connected by the secondary structures or paratormae (*pta.*) with the posterior part of the fulcrum—the pharynx (*ph.*). In the Hippoboscidae the tormae are fused together and either attached to the anterior border or to the middle of the fronto-clypeus. In the Nycteribiidae the position of the fulcrum is the same as in the above mentioned family, whereas the tormae are separated each from the other and are attached to the proboscis membrane at the lateral borders of the fronto-clypeus. Posteriorly each torma is fused with the paratorma but the suture produced by this fusion is obsolete. The paratormae represent the curved chitinous bars of which the posterior ends are slightly broadened and fused with the lateral borders of the pharynx. The pharynx of the Nycteribiidae has practically the same structure as that of the Muscidae and the Hippoboscidae. It is composed of an oblong posterior part which is concave and strongly chitinised, and an anterior membranous part. The latter is attached laterally to the borders of the posterior part of the pharynx and has in the middle the median plate (*m.p.*) into which are inserted the *dilators of the pharynx* (*d.ph.*). These are very strong muscles. They arise not only from the tormae, as in the Muscidae and the Hippoboscidae, but also from the antero-lateral parts of the fronto-clypeus and the rostrum membrane. The lumen of the pharynx is continuous anteriorly through the hyoid with the food canal of the haustellum and posteriorly with the lumen of the oesophagus (*o.*). The anterior end of the oesophagus is surrounded by the *sphincter of the oesophagus* (*sph.o.*). This muscle, apparently, is present in all the blood-sucking Diptera, since it has been found in the Hippoboscidae and in all the blood-sucking Nematocera (Jobling, 1926 and 1928). From the pharynx the oesophagus extends downwards along the anterior part of the supraoesophageal ganglion and then, bending upwards, passes through the canal of the brain between the supraoesophageal (*sp.g.*) and suboesophageal (*sb.g.*) ganglions. In the posterior part of the head capsule it extends along the dorsal surface of the suboesophageal ganglion and the cephalothoracic nerve cord towards the proventriculus.

The hyoid (*hy.*) represents the secondary structure which connects the pharynx with the labrum-epipharynx. In the Hippoboscidae the hyoid is much better developed than in all the other Diptera which have this structure, and its development is undoubtedly closely connected with the development of the protractability of the proboscis (Jobling, 1926). In the Nycteribiidae the proboscis does not protract so far as in the above mentioned family and the hyoid is therefore very much shorter. In *Cyclopodia sykesi* the hyoid is represented by a narrow tube which has the ventral wall much thicker than the dorsal. Its posterior end is attached to the anterior part of the pharynx, whereas anteriorly it becomes membranous and is continuous with the epipharynx, being fused ventrally with the posterior end of the labial gutter immediately above the point of attachment of the common salivary duct.

The *common salivary duct* (*c.s.d.*) of the Nycteribiidae has no spiral taenidia; it is composed of a very thin intima and a single layer of the hypodermic cells. Not far from its point of attachment to the labial gutter it is dilated, forming a bulb-shaped *salivary valve* (*s.v.*). The latter is provided with two *salivary valve muscles* (*s.v.m.*) which arise, as in the other blood-sucking Diptera, from the postero-lateral parts of the pharynx.

THE MUSCLES OF THE ROSTRUM (Pl. XIV, fig. 1).

The muscular system of the rostrum of the Nycteribiidae is very well developed and includes several sets which are absent in the head of the Hippoboscidae. As in the latter family, the protraction of the proboscis depends entirely on the action of the muscles of the rostrum, and not on the respiratory system as in the Muscidae. The respiratory system is, indeed, very poorly developed and there are no large air sacs in the anterior part of the head, which is occupied almost entirely by the chitinous structures of the rostrum and their muscles. The muscles of the fronto-clypeus are described together with those of the rostrum, the action of both sets being closely connected.

The *depressors of the fronto-clypeus* (*d.fc.*). These are small muscles arising from the anterior part of the vertex not far from the ocular sclerite and inserted into the postero-ventral part of the fronto-clypeus.

The *elevators of the fronto-clypeus* (*e.fc.*) are of the same size as the depressors. Each muscle arises from the postgenae immediately behind the ocular sclerite and is inserted into the postero-lateral border of the fronto-clypeus. Massonnat (1909) incorrectly described the elevators of the fronto-clypeus as the retractors of the antennae in *Nycteribia* sp. The homology of these muscles is uncertain; they apparently belong to the antennal muscles of which the points of attachment have been modified.

The *depressors of the fulcrum* (*d.f.*) are homologous with the same muscles in the Hippoboscidae. They are represented by very strong bands arising from the latero-posterior part of the pharynx and inserted into the lower part of the gena not far from its anterior border.

The *elevators of the hyoid* (*e.hy.*). These are represented by two very strong bands. Each band arises from the paratorma and is inserted into the dorsal surface of the hyoid. The homology of these muscles is not clear.

The *elevators of the stipites* (*e.s.*). Each of these muscles is represented by a very small band arising from the post-palpal plate and inserted into the posterior end of the stipes. These muscles are probably homologous with the elevators of the stipites in the Hippoboscidae.

The *depressors of the stipites* (*d.s.*). These muscles arise from the antero-lateral parts of the hyoid. Each of them is inserted into the posterior end of the stipes. They are apparently homologous with the elevators of the hyoid in the Hippoboscidae, since they have the same points of attachment.

The *retractors of the stipites* (*r.s.*) arise from the antero-lateral border of the pharynx immediately below the posterior part of the paratorma and are

inserted into the stipes above the retractor of the rostrum. They are probably homologous with the same muscles in the Hippoboscidae.

The *elevators of the post-palpal plates* (*e.pp.p.*) are represented by very broad bands arising from the paratorma and inserted into the post-palpal plate. The homology of these muscles is not clear.

The above described muscles serve to protract the proboscis, but they do not contract simultaneously. The elevators of the hyoid contract first and unbend the hyoid, which, being attached to the posterior part of the haustellum, pushes the latter from the head capsule. The elevators and the depressors of the stipites act together during the depression of the haustellum, whereas the retractors of the stipites and the elevators of the post-palpal plates are their antagonists. When the haustellum is protracted by the elevators of the hyoid, the further protraction of the proboscis is effected by the depressors of the fulcrum, which are the strongest muscles of the rostrum. During the extension of the proboscis, the fronto-clypeus is elevated by its own muscles and occupies almost the horizontal position, making room for the chitinous parts and the muscles of the rostrum to be protracted from the head capsule. This elevation of the fronto-clypeus takes place also in the most specialised of the Hippoboscidae, where it is effected by the muscles of the rostrum.

The *retractors of the haustellum* (*r.h.*). These are very long muscles and are homologous with the same muscles in the Hippoboscidae. Each of them arises from the postgena at the posterior border of the membranous part of the head surrounding the eye, and is inserted into the posterior border of the theca.

The *retractors of the rostrum* (*r.r.*). These are the longest muscles of the head and are homologous with the same muscles in the Hippoboscidae. Each muscle arises from the thick postero-ventral part of the postgena and is inserted into the anterior part of the stipes immediately below its retractor.

As regards the action of these muscles during the retraction of the proboscis, it becomes apparent that the retractors of the haustellum contract first and in so doing withdraw the haustellum upwards. With these muscles cooperate the retractors, the depressors of the stipites and the elevators of the post-palpal plates. The first two sets of muscles elevate the haustellum and depress the stipites, whereas the elevators of the post-palpal plates retract the rostrum membrane. After the haustellum is partly retracted and occupies a position parallel to the longitudinal axis of the head, it is retracted further by the action of the retractors of the rostrum. When the proboscis is at rest the bulbous part of the haustellum lies above the inner borders of the postgenae in the depression formed by the retracted rostrum membrane, its narrow part occupying the position between the maxillary palps.

The Haustellum (Pls. XV and XVI).

The parts of the haustellum of the Nycteribiidae which morphologically belong to the labium, *i.e.* the theca (*th.*) and the labial gutter (*l.g.*), are developed on the same plan as those of the Hippoboscidae, though they differ

from them very much in detail. The theca is the external part of the haustellum; its anterior half is very narrow, whereas the posterior half is bulb-shaped. The ventral surface of the latter is strongly chitinised and bears four very long setae on its anterior part. Immediately behind these setae there are present four small and slightly curved sensillae. Sensillae of the same type are also present along the postero-ventral border of this part of the theca. The dorsal surface of the bulb differs anatomically from that of the Hippoboscidae; it is not entirely chitinised and rigid as in the latter family, but is subdivided by the membrane into several pieces (Pl. XV, fig. 5). Of these pieces the two antero-dorsal ones (*ad.pc.*) represent each an oblong plate which bears two very long setae on its anterior part. At its posterior border there is present the sensory plate (*s.p.*), which has seven or eight basally very short and broad sensillae. The lateral surfaces of the bulb are each subdivided into an antero-lateral and a postero-lateral piece which are more or less triangular in outline and bent over the dorsal surface of the theca. The antero-lateral piece (*al.pc.*) is continuous with the narrow anterior part of the theca and from its inner surface arises a curved process (*pr.th.*) into which is inserted the retractor of the theca. The postero-lateral piece (*pl.pc.*) is the larger; it ends near the postero-lateral part of the labrum-epipharynx and, together with the latter and the postero-ventral border of the theca, serves for the attachment of the rostrum membrane.

The narrow anterior half of the theca does not represent the chitinised gutter, as in the Hippoboscidae, but is composed of two thick lateral plates which are connected ventrally by a membrane along their entire length (Pl. XVI, figs. 8 and 9). This membrane has originated through the modification of the ventral surface of the theca and is continuous with the membrane of the labella. Internally the narrow part of the theca is separated by a membrane (*m.*) from the cavity of the bulb. This membrane arises like a septum round the labial gutter and, enveloping the latter, extends towards the anterior part of the bulb, where it is attached to its inner walls (Pl. XVI, figs. 10 and 11).

The labial gutter forms the inner part of the haustellum, in which are enclosed the labrum-epipharynx and the hypopharynx. Its position and structure differ from that in the Hippoboscidae. In the latter family it occupies the dorsal position with regard to the theca, with the exception of its most anterior part which lies in the middle of the labella, while in the Nycteribiidae the gutter is completely inside the theca, being covered by the interlocked folds of the membrane dorsally. Each part of the membrane connects the dorsal border of the labial gutter with the dorsal border of the lateral plate of the theca, being continuous anteriorly with the membrane of the labella and posteriorly with the membrane of the dorsal surface of the bulb (Pl. XVI, figs. 8–14). The posterior part of the labial gutter is very thick and is connected by the hyaline filament with the postero-ventral border of the theca. From the ventral surface of this part of the gutter arises a very thick hook-shaped process into which are inserted the protractors of the labial gutter (Pl. XIV, fig. 1).

The parts of the gutter which surround the labrum-epipharynx laterally are bent over the dorsal surface of the bulbous part of the haustellum, where they form triangular pieces connected by the membrane with the chitinised part of the theca. In the middle part of the bulb, immediately in front of the labrum-epipharynx, the labial gutter becomes narrower. Its ventral part forms the thick-walled and rounded food canal, whereas the dorsal part, which is partly membranous, encloses the hypopharynx. Below the narrow anterior part of the labrum-epipharynx, the ventral wall of the food canal is perforated by seven or eight very minute canals of the labial glands (Pl. XV, fig. 6).

The *labial glands* (*l.gl.*) occupy the middle part of the cavity of the bulb, above the protractors of the labial gutter. Each gland is pyriform and is composed of many gland cells. The cytoplasm of the cells is vacuolated and possesses a large nucleus. In the total preparation of the gland, stained with acid haemalum and counter-stained with an alcoholic solution of eosin, it is possible to see the intercellular duct, which communicates through the narrow part of the gland with the canal of the ventral wall of the labial gutter. The labial glands have also been described by Lowne (1895) in *Calliphora erythrocephala* Meig., by Kraepelin (1883) and subsequently by Graham-Smith (1911) and Hewitt (1914) in *Musca domestica* Linn. In all these flies the glands are situated in the anterior part of the haustellum and their ducts open into the oral pits. Nothing is known definitely about the secretion of the glands, though Hewitt believes that they serve to keep the surface of the oral lobes moist. In the blood-sucking flies, such as the Nycteribiidae, it is more probable that these glands produce an anti-coagulin which prevents the coagulation of the blood in the very narrow food canal of the haustellum.

The *hypopharynx* (*h.*), as in the Hippoboscidae, arises from the posterior part of the labial gutter. This very slender and hyaline mouth-part is perforated by the salivary duct which opens at its anterior end. It is seen in the drawing of the transverse section of the haustellum (Pl. XVI, fig. 14) that the hypopharynx is asymmetrical in its posterior part and lies on the floor of the labial gutter. A little further under the anterior part of the labrum-epipharynx the hypopharynx curves upwards and twists round until its narrow lateral edge occupies the dorsal position; it then becomes enclosed in the upper part of the labial gutter (Pl. XVI, figs. 8–13).

The *labrum-epipharynx* (*lep.*) of the Nycteribiidae differs from that of the Hippoboscidae. In the latter family it is very long and greatly resembles the labrum-epipharynx of the genera *Stomoxys* and *Glossina*, whereas in the former it is very short and extends anteriorly only to the middle of the bulbous part of the haustellum. The labrum-epipharynx of *Cyclopodia sykesi* somewhat resembles a spear-head (Pl. XIV, fig. 1), but when viewed laterally it has the shape of a penknife blade. It is seen in the transverse sections of the haustellum that the posterior part of the labrum-epipharynx is broad and nearly square, while its anterior part is flattened laterally and very narrow. The dorsal convex and the lateral concave parts of the labrum-epipharynx belong morphologically

to the labrum, but the ventral part, which is guttered dorsally and overlaps the hypopharynx, is the greatly modified epipharynx (*ep.*). The latter is continuous posteriorly with the hyoid and, as in many other Diptera, bears very minute sensillae which project into the food canal of the haustellum. The labrum-epipharynx is an immovable mouth-part, since it is fused with the hyoid and, by the postero-ventral part of the labrum, with the basal part of the labial gutter. The structure of this mouth-part is slightly variable in the Nycteribiidae. In the genus *Nycteribia* it has the same form as in *Cyclopodia*, but in *Penicillidia jenynsi* the anterior end of the labrum-epipharynx terminates bluntly and the dorsal surface is very broad and strongly convex in its posterior part.

THE LABELLA (Pls. XV and XVI).

These parts of the proboscis are unrecognisably modified from the more generalised type of the labella of the Diptera and they also differ in their structure from those found in the Hippoboscidae. In the latter family the labella represent the chitinised gutter, while in the Nycteribiidae they are entirely membranous. The dorsal parts of the membranous walls of the labella are separated from each other. Posteriorly each of them is continuous with the membrane of the dorsal part of the haustellum and has the same attachment to the dorsal border of the labial gutter. The lateral and the ventral parts of the walls of the labella arise respectively from the anterior border of the chitinised plates and the ventral membranous part of the theca. In the retracted labella the outer walls project anteriorly and then bend inwards, forming inner walls which are attached to the frontal border of the labial gutter. The lateral surface of each labellum is grooved longitudinally, forming five serrated ridges. The latter bear rows of chitinised teeth (*te.r.*) which closely resemble those of the serrated ridges of the labella of the Hippoboscidae. These teeth are of different sizes; the largest ones occupy the top row, whereas towards the bottom of the longitudinal groove the teeth of each row become smaller. They also decrease in size in each row towards the anterior border of the labial gutter (Pl. XV, figs. 3 and 4). Besides the above described teeth there are present very narrow and long spines on the inner walls at the frontal edge of the gutter, but they are seen only when the labellum is protracted.

The main armature of both labella consists of six prestomal and two inner teeth. The prestomal teeth (*p.to.*) are flat and triangular in form; they terminate in two distinct denticules and are arranged radially on the membrane of the labella not far from the frontal edge of the labial gutter. The inner teeth (*i.to.*) are twice as long as the prestomal; they are flat and bifurcated in their basal parts. The lower branch of the bifurcated base articulates with the lateral part of the edge of the labial gutter, and the upper branch with the membrane of the lateral wall of the labellum. This means of articulation allows a very wide range of lateral rotation to the tooth during the protractions and retractions of the theca (Pl. XV, fig. 3).

Immediately behind the prestomal teeth of each labellum there are present six gustatory sensillae (*g.s.*). Being very long, they are the most conspicuous structures of the anterior ends of the labella when these are protracted (Pl. XV, fig. 4; Pl. XVI, fig. 7). The sensillae are very weakly chitinised and very flexible; each of them is connected by a very long and narrow chitinous structure, the intralabial caniculus (*il.c.*), with the cell located in the cavity of the bulbous portion of the haustellum. The caniculi arise from the membrane which separates the cavity of the bulb from that of the narrow part of the haustellum. Towards the anterior part of the bulb they become more distinct, being arranged in four groups. Each group consists of three caniculi fused together (Pl. XVI, figs. 10 and 11). In the cavity of the narrow part of the haustellum the wall of each group is very strongly chitinised, but in the anterior part it becomes membranous again and each two groups of the caniculi fuse together and surround the labial gutter laterally (Pl. XVI, fig. 8). The intralabial caniculi serve to protect the protoplasmatic threads which pass through the narrow part of the haustellum from the sense cells to the gustatory sensillae of the labella.

The Muscles of the Haustellum and the Mechanism of the Labella.

The cavity of the narrow part of the haustellum and the labella (which is separated by the membrane from that of the bulb) is absolutely devoid of any living tissue. This apparently degenerates during the last pupa stage, since in the transverse sections of the haustellum it is possible to see vacuolated inclusions scattered here and there in the cavity between the labial gutter and the theca. The disappearance of the tissue is probably connected with the great reduction of the space between the gutter and the theca and the extensive mobility of these parts during feeding. The muscles of the haustellum are concentrated in the cavity of the bulb; they are very well developed and are arranged in the same sets as those of the Hippoboscidae.

The *retractors of the theca* (*r.th.*) are homologous with the retractors of the labella of the Hippoboscidae (Jobling, 1926). These muscles arise from the postero-lateral parts of the bulb and each of them is inserted into the process of the theca (*pr. th.*).

The *protractors of the labial gutter* (*p.lg.*) are homologous with the same muscles of the Hippoboscidae. They arise from the process of the postero-ventral part of the labial gutter and occupy the middle of the cavity of the bulb, being inserted into the antero-ventral part of the bulbous portion of the theca.

The *retractors of the labial gutter* (*r.lg.*) are homologous with the same muscles of the Hippoboscidae. Each of them arises from the postero-lateral part of the theca, immediately above the retractor of the theca, and is inserted into the lateral part of the labial gutter, which surrounds the labrum-epipharynx laterally (Pl. XVI, figs. 14 and 15).

The cutting action of the teeth of the labella in the Nycteribiidae depends

entirely upon the movement of the anterior part of the theca. The labial gutter, as in the Hippoboscidae, is immovable in respect of the hyoid. When the retractors of the theca contract, they pull the anterior part of the theca along the labial gutter backwards. The further retraction of this part is effected by the contraction of the protractors of the labial gutter.

It has been pointed out in the description of the haustellum that the dorsal surface of the bulbous part of the theca is divided into several pieces which are separated by the wide membranous spaces. This modification of the bulb develops parallel with the retractability of the narrow anterior part of the theca, otherwise the motion of this part would be greatly limited. During the retraction of the anterior part of the theca, its bulbous portion becomes much shorter and more globular. This is effected by the retraction of the antero-dorsal and the antero-lateral pieces towards the postero-lateral ones, and the increase in convexity of the ventral wall of the bulb. The protraction of the anterior part of the theca depends upon the contraction of the retractors of the labial gutter and the rigidity of the ventral wall of the bulb.

The motion of the theca causes the inner walls of the labella to become alternately everted and inverted. As the teeth are attached to the surfaces of these walls they perform protrusible divergent movements. The serrated ridges of the labella apparently act like a file in scraping the skin and also fix the proboscis to the bottom of the puncture. The main cutting action is performed by the prestomal and the strongest inner teeth. When the mouth-parts are at rest the membranous walls of the labella are inverted and the opening into the food canal of the haustellum is closed by the retracted inner teeth (Pl. XV, fig. 3), but in the protracted labella the pointed ends of the teeth of the serrated ridges are directed backwards towards the head, whereas the prestomal and the inner teeth together with the gustatory sensillae are pointed laterally (Pl. XV, fig. 4; Pl. XVI, fig. 7).

SUMMARY.

The investigation deals in detail with the structure of the immovable and movable parts of the head of the Nycteribiidae. The muscles of the head are also studied.

The head capsule is modified from that of the Hippoboscidae. The vertex is not subdivided into several anatomically differing subregions. The occiput is represented by the border of the occipital foramen only. The postgenae are separated by the median membranous region of the head, as in the Hippoboscidae. The ptilinum serves as a flexible joint connecting the fronto-clypeus with the vertex and the genae. The fronto-clypeus is much more modified than that of the Hippoboscidae and is movable. The eyes are reduced to one or two facets, or are entirely absent. The greatly modified ocular sclerites are present in *Cyclopodia* only.

The antennae consist of the pedicle and the flagellum, the latter being

concealed in the cavity of the former. They have the same structure as those of the Hippoboscidae parasitising birds.

The proboscis has much in common with that of the Hippoboscidae though it differs greatly in detail. It is composed of the rostrum, the haustellum and the labella.

The rostrum belongs morphologically to the head and is formed of the same parts as in the Hippoboscidae. All the parts of the rostrum, with the exception of the tormae, have the same arrangement as in that family. The tormae are separate and are attached at the lateral borders of the fronto-clypeus.

The haustellum is composed of the theca, the labial gutter, the labrum-epipharynx and the hypopharynx. The two former parts belong morphologically to the labium, but differ in detail from those of the Hippoboscidae. The very short labrum-epipharynx is enclosed in the posterior part of the labial gutter.

The hypopharynx is very slender and as long as the theca; it is enclosed in the cavity formed by the dorso-lateral parts of the labial gutter.

Labial glands are present in the bulbous part of the theca; their ducts open into the food canal. All the muscles of the bulbous part of the haustellum are homologous with those of the same part of the proboscis of the Hippoboscidae.

The labella are entirely membranous, are armed with two inner and six prestomal teeth and their surfaces have serrated ridges. There are six gustatory sensillae on the membrane of each labellum, which are connected by the intralabial canaliculi with the sense cells of the bulbous part of the theca.

The cutting action of the teeth of the labella depends upon the protractions and retractions of the narrow part of the theca. When this part retracts it everts the inner membranous walls of the labella, and the teeth, being attached to these walls, perform protrusible divergent movements.

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EXPLANATION OF PLATES.

PLATE XIV.

Cyclopodia sykesi Westw.

Fig. 1. Right half of head, showing muscles of fronto-clypeus, antennae, rostrum and haustellum. × 180.

Fig. 2. Labrum-epipharynx, showing attachment of stipes (*s.*). × 480.

PLATE XV.

Cyclopodia sykesi Westw.

Fig. 3. Diagram of longitudinal section through labella and anterior part of haustellum. × 960.

Fig. 4. Dorsal view of protracted labella. × 960.

Fig. 5. Dorsal view of haustellum, narrow anterior part represents diagrammatically its longitudinal section. × 240.

Fig. 6. Labial glands (*l.gl.*) and their attachment to ventral wall of labial gutter (*l.g.*). × 480.

PLATE XVI.

Cyclopodia sykesi Westw.

Fig. 7. End view of protracted labella, showing teeth and gustatory sensillae (*g.s.*) everted. × 960.

Fig. 8. Transverse section through anterior part of haustellum. × 600.

Fig. 9. Transverse section through middle part of haustellum. × 600.

Fig. 10. Transverse section through anterior part of bulb, where processes of theca (*pr.th.*) become fused with antero-dorsal pieces (*ad.pc.*) and ventral part of bulb. × 360.

Fig. 11. Transverse section through anterior part of bulb, showing membrane (*m.*) which separates cavity of bulb from that of narrow part of haustellum. × 360.

Fig. 12. Transverse section through middle of bulb, showing position of labial gland (*l.gl.*) under labial gutter (*l.g.*). × 360.

Fig. 13. Transverse section through middle of bulb, showing position of anterior part of labrum-epipharynx (*lep.*). × 360.

Fig. 14. Transverse section through posterior part of bulb, showing position of labrum-epipharynx (*lep.*), hypopharynx (*h.*) and muscles of haustellum. × 360.

Fig. 15. Transverse section through posterior part of labial gutter, showing position of labrum-epipharynx (*l.* + *ep.*) and attachment of protractors and retractors of labial gutter. Here hypopharynx (*h.*) becomes separated from the gutter. × 600.

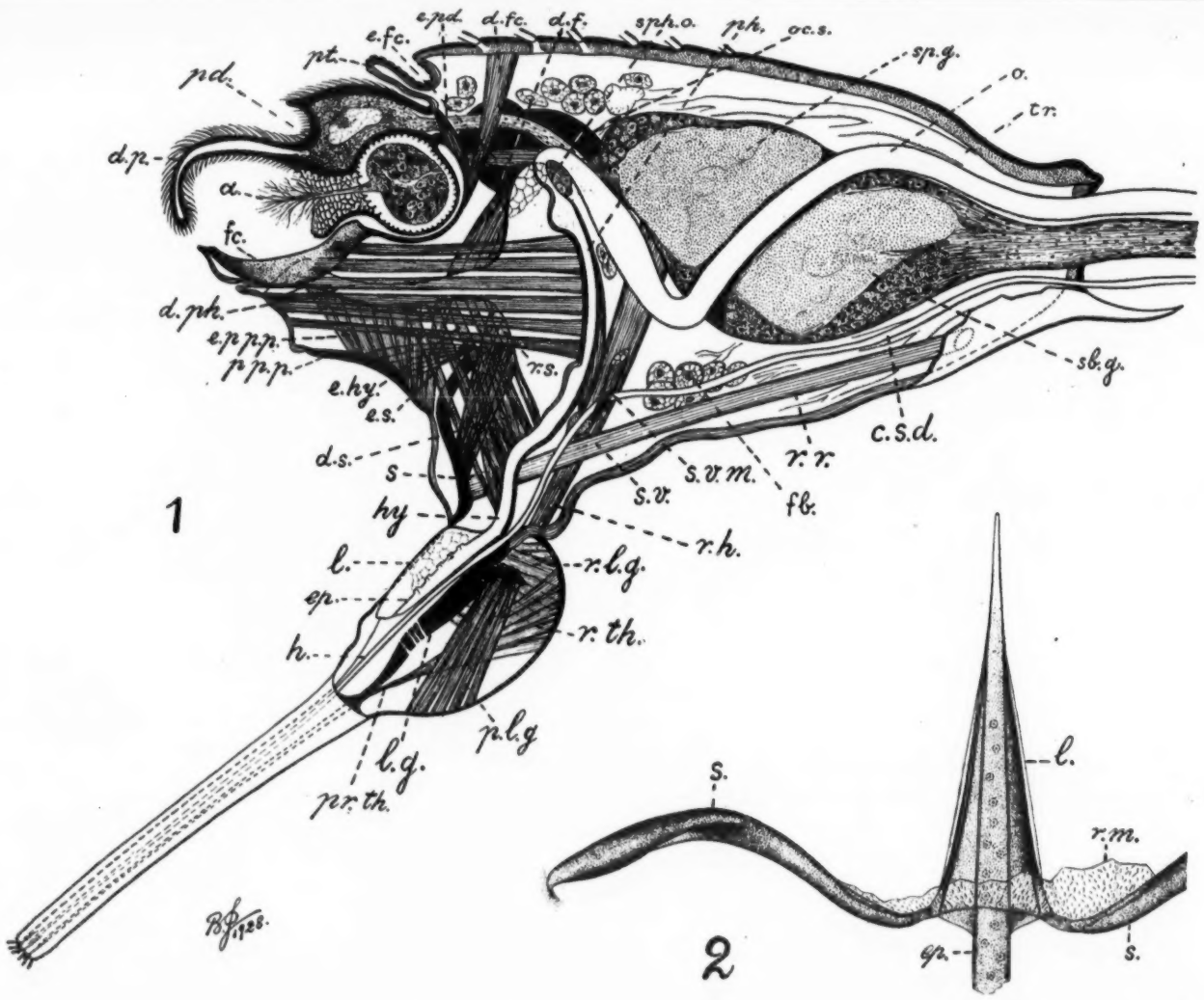
Fig. 16. Transverse section through base of labial gutter, it is penetrated by salivary duct (*s.d.*) and becomes fused with lateral parts of labrum (*l.*). Epipharynx (*ep.*) forms dorsal wall of food canal (*f.cn.*). × 600.

EXPLANATION OF REFERENCE LETTERING.

a. arista.
ad.pc. antero-dorsal piece.
al.pc. antero-lateral piece.
a.p. antennal pit.
c.s.d. common salivary duct.
d.f. depressor of fulcrum.
d.fc. depressor of fronto-clypeus.
d.p. dorsal prolongation of pedicle.
d.ph. dilator of pharynx.
d.s. depressor of stipes.
e. eye.
e.fc. elevator of fronto-clypeus.
e.hy. elevator of hyoid.
ep. epipharynx.
e.pd. elevator of pedicle.
e.pp.p. elevator of post-palpal plate.
e.s. elevator of stipes.
f. fulcrum.
f.b. fat body.
f.c. fronto-clypeus.
f.cn. food canal.
g. gena.
g.s. gustatory sensilla.
h. hypopharynx.
hy. hyoid.
hyp.c. hypodermic cell.
il.c. intralabial canaliculus.
i.to. inner tooth.
l. labrum.
lab. labella.
lc.s. latero-cervical sclerite.
lep. labrum-epipharynx.
l.g. labial gutter.
l.gl. labial gland.
l.n. labial nerve.
m. membrane.

m.p.	median plate of pharynx.
o.	oesophagus.
oc.s.	ocular sclerite.
o.f.	occipital foramen.
o.s.	olfactory sensilla.
p.	palp.
pd.	pedicle.
pg.	postgena.
ph.	pharynx.
p.l.g.	protractor of labial gutter.
pl.pc.	postero-lateral piece.
pp.p.	post-palpal plate.
pr.fc.	process of fronto-clypeus.
pr.th.	process of theca.
pt.	ptilinum.
pta.	paratorma.
p.to.	prestomal tooth.
r.h.	retractor of haustellum.
r.lg.	retractor of labial gutter.
r.m.	rostrum membrane.
r.r.	retractor of rostrum.
r.s.	retractor of stipes.
r.th.	retractor of theca.
s.	stipes.
sb.g.	suboesophageal ganglion.
s.d.	salivary duct.
s.p.	sensory plate.
sp.g.	supraoesophageal ganglion.
sph.o.	sphincter of oesophagus.
s.v.	salivary valve.
s.v.m.	salivary valve muscle.
t.	torma.
te.r.	teeth of serrated ridge.
th.	theca.
tr.	trachea.
v.	vertex.

(*MS. received for publication* 23. v. 1928.—Ed.)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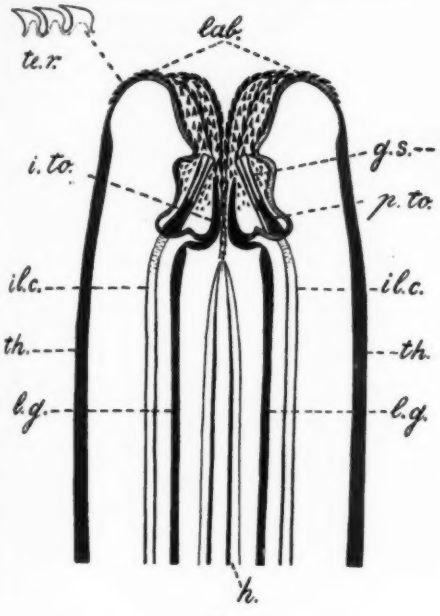

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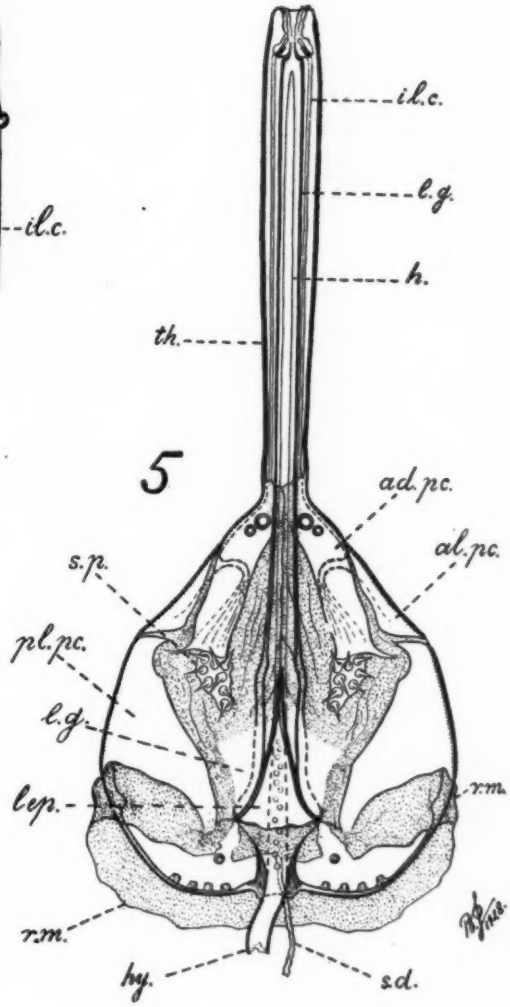

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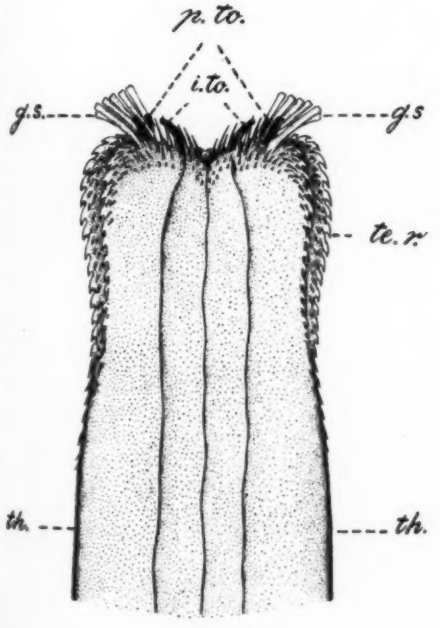

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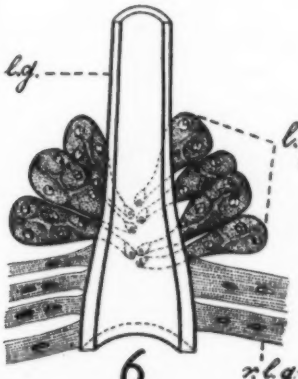

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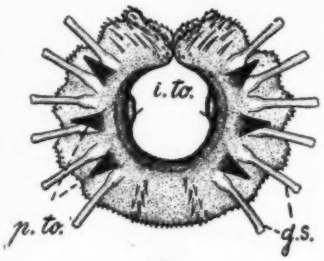

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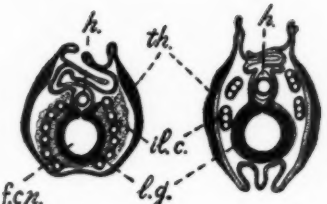

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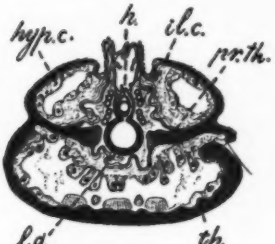

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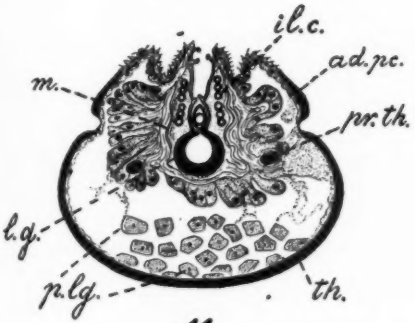

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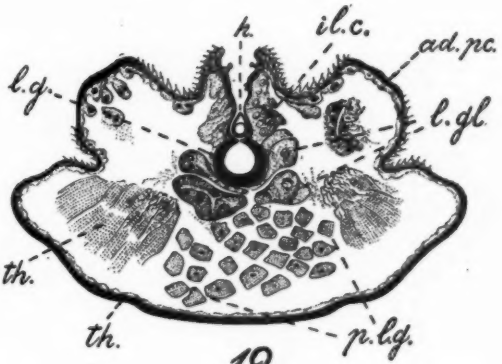

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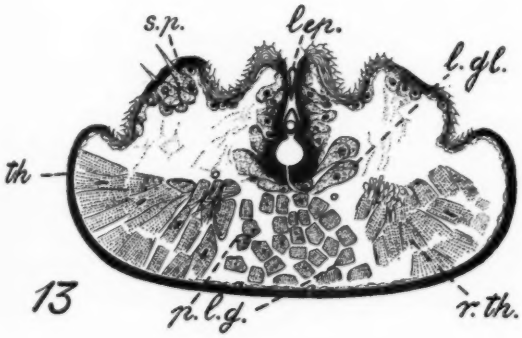

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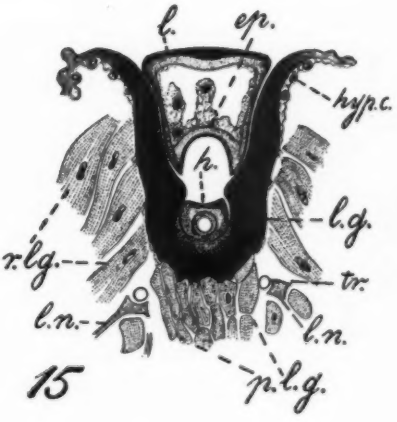

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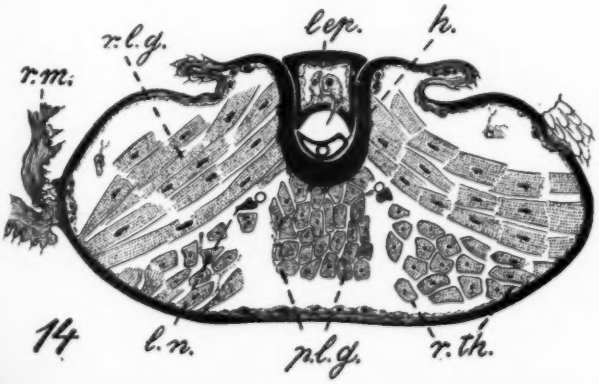

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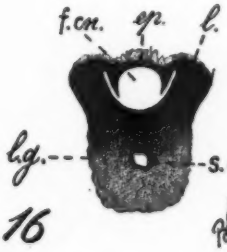

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THE GENERA *CHAROPINUS* AND *LERNAEOPODINA* (COPEPODA) AS REPRESENTED BY THE COLLECTION IN THE BRITISH MUSEUM.

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(With 6 Text-figures.)

The two genera here considered agree with one another and differ from all the other members of the Lernaeopodidae in having the abdominal appendages dorsal to the eggstrings; and all their species so far described are parasitic upon some species of ray.

Genus **Charopinus** Krøyer (1863).

Generic Diagnosis ♀. *Cephalothorax* elongate, cylindrical, indistinctly segmented by faint transverse constrictions behind the cephalon; except in one species (*C. ramosus*) turned back at right angles or even against the dorsal surface of the trunk, as in some species of *Clavella*; a dorsal carapace only in *C. bicaudatus*. *Trunk* pyriform or elongated, often flattened posteriorly, the first segment clearly marked, differentiating a distinct neck behind the second maxillae. *Abdominal appendages*, one pair, dorsal to the eggstrings, which are as long or longer than the trunk. Abdomen small. No genital process nor anal laminae. *Second maxillae* very long, slender, removed some distance behind maxillipedes. *Bulla* very variable. *Maxillipedes* large and prominent with a short terminal claw shutting against a projection on the second article.

C. dalmanni (Retzius 1829).

Material. (*a*) 2 ♀♀, 1913. 9. 18. 428–429[1], from the nasal fossae of *Raia batis* taken in the North Sea. From one of these Fig. 1 is drawn.

Dimensions: Cephalothorax 12·8 mm., second maxillae 21·4 mm., trunk 15 mm., abdominal appendages 11 mm., eggstrings 13·5 mm.

(*b*) 10 ♀♀, 48448–457, from the nostrils of a skate from Polperro, presented by Laughrin, Norman Collection.

[1] The numbers cited after the specimens refer to the Register in the British Museum, Crustacea Department.

Diagnosis ♀. *Cephalothorax* elongated, curved abruptly backwards so as nearly to touch the dorsal surface of the trunk. *Neck* dilated. *Trunk* sub-pyriform increasing in size posteriorly, the postero-lateral corners forming bluntly-rounded knobs. *Abdominal appendages* of moderate length and strongly curved. *Eggstrings* cylindrical, nearly as long as trunk. *Second maxillae* extremely long, corrugated, base spherical and lateral, gradually tapering and becoming very slender, abruptly expanding at the apex each into

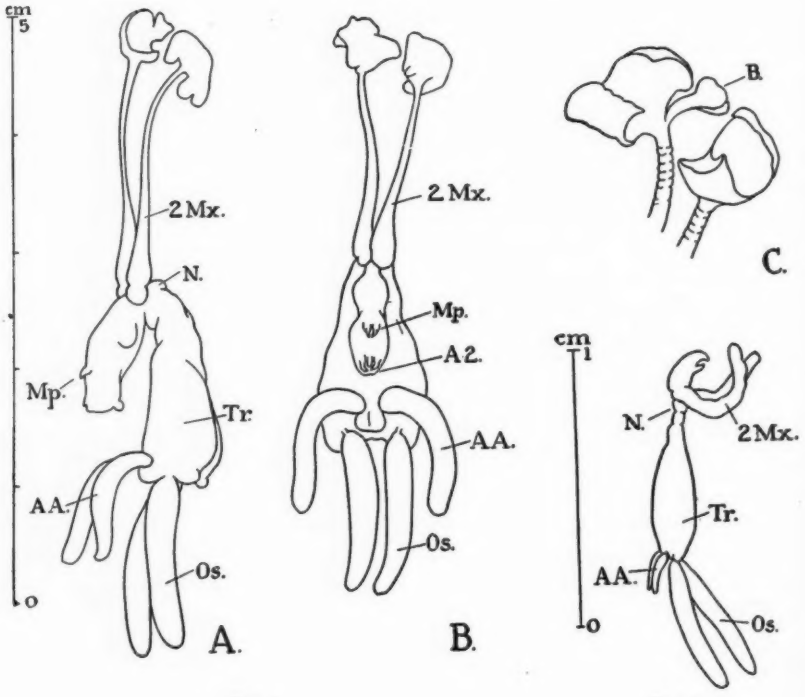

Fig. 1. Fig. 2.

Fig. 1. *Charopinus dalmanni* ♀. A. in right lateral aspect. B. in dorsal aspect. C. enlarged apices of second maxillae. *A* 2. = antennae; 2 *Mx.* = second maxillae; *B.* = bulla; *N.* = neck; *Mp.* = maxillipedes; *Tr.* = trunk; *AA.* = abdominal appendages; *Os.* = eggstrings.

Fig. 2. *Lernaeopodina similis* ♀. *N.* = neck; 2 *Mx.* = second maxillae; *Tr.* = trunk; *AA.* = abdominal appendages; *Os.* = ovisacs.

a semilunar disc. The discs fit closely together, and in one of the specimens (*a*) there arises from the base of one disc a separate portion of cartilaginous appearance which appears to be the homologue of the *bulla* or at least the vestige of the frontal filament. (Fig. 1 c, *B.*)

C. dubius T. Scott (1900).

Material. (*a*) 4 ♀♀, 1913. 9. 18. 430–433, from the Clyde, North Sea and Irish Sea on the gills of *Raia circularis* and *R. fullonica*.

(*b*) 2 ♀♀ (incomplete), 48459–460. T. Scott's types from the Firth of Clyde on the gills of *Raia circularis* Dec. 1899.

Dimensions of the best specimen in group (*a*) (Fig. 3): cephalothorax 6·9 mm., trunk 6 mm., second maxillae 9·5 mm., width of bulla 9·1 mm., abdominal appendages 3·6 mm., eggstrings 11·5 mm.

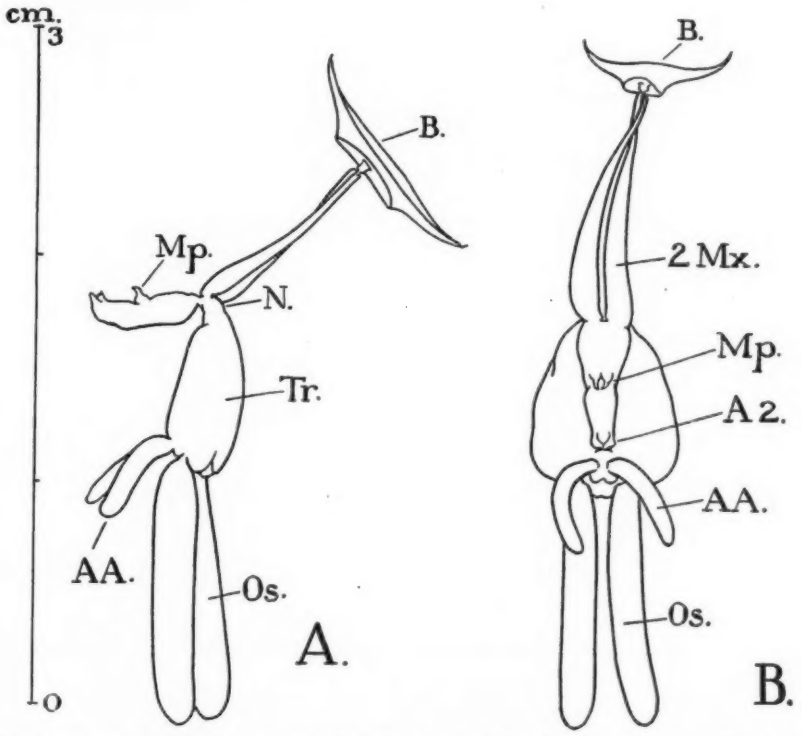

Fig. 3. *Charopinus dubius* ♀. A. in right lateral aspect; B. in dorsal aspect. *Mp.* = maxillipedes; *B.* = bulla; *N.* = neck; *Tr.* = trunk; *AA.* = abdominal appendages; *Os.* = eggstrings; *A* 2. = antennae; 2*Mx.* = second maxillae.

Diagnosis ♀. *Cephalothorax* slender, bent dorsally at right angles to the trunk. *Trunk* ovate, rounded posteriorly. *Abdominal appendages* cylindrical, one-third the length of the *eggstrings* which are nearly twice the length of the trunk. *Second maxillae* elongated, slender and tapering, much longer than trunk. *Bulla* chitinous, dark brown, canoe-shaped with upcurved extremities; manubrium well marked.

C. ramosus Krøyer (1863).

Material. (*a*) 1 ♀, 1913. 9. 18. 434, labelled from the North Sea and Irish Sea on the gills of *Raia clavata* and *R. maculata* (!).

Dimensions: cephalothorax 1·3 mm., trunk 6·3 mm., second maxillae 6·7 mm., abdominal appendages 1 mm., eggstrings 5·6 mm. (Fig. 4).

(*b*) 1 ♀, 48458, from the North Sea on the gills of *R. maculata*, 1900, Norman Collection; presented by T. Scott.

Diagnosis ♀. *Cephalothorax* small, in same straight line with the trunk. *Neck* elongated. *Trunk* long and narrow, wider posteriorly. *Abdominal*

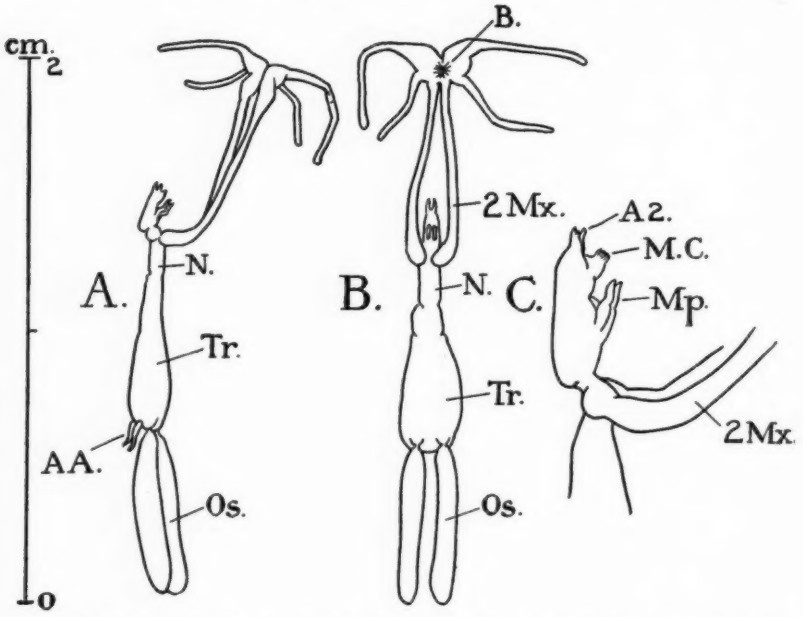

Fig. 4. *Charopinus ramosus* ♀. A. in right lateral aspect. B. in ventral aspect. C. enlarged lateral view of head. *A 2.* = antennae; *M.C.* = mouth cone; *Mp.* = maxillipedes; *2 Mx.* = second maxillae; *B.* = bulla; *N.* = neck; *Tr.* = trunk; *AA.* = abdominal appendages; *Os.* = eggstrings.

appendages minute. *Eggstrings* cylindrical, as long as trunk. *Second maxillae* elongated, slender, of about the same width throughout, no spherical base, apices coherent on their inner surfaces, their outer each extending into two long processes or horns. At the point where they touch a lens reveals a star-shaped mark, not previously recorded, which represents the frontal filament and can be regarded as a vestigial bulla. I suggest this stellate branching is homologous with the channellings in the bulla of *Clavella* (first described by me in 1925). *Mouth-cone* prominent (Fig. 4 C, *M.C.*). *Maxillipedes* standing well out in front of mouth-cone (Fig. 4 C, *Mp.*).

C. bicaudatus (Krøyer, 1837).

Material. 2 ♀♀, 1913. 9. 18. 479–480, in the nasal fossae of *Trygon pastinaca* from Dornoch Firth presented by T. and A. Scott.

Dimensions: head and cephalic neck 3 mm., trunk 3·5 mm., second maxillae 1 mm., abdominal appendages 0·5 mm., eggstrings 4·8 mm. (Fig. 5).

Diagnosis ♀. *Cephalothorax* long, the distance between maxillipedes and second maxillae narrowed to a cephalic neck, the whole bent dorsally at right angles to the trunk; a well-marked narrow dorsal carapace divided longitudinally through the centre, the halves closely resembling the elytra of

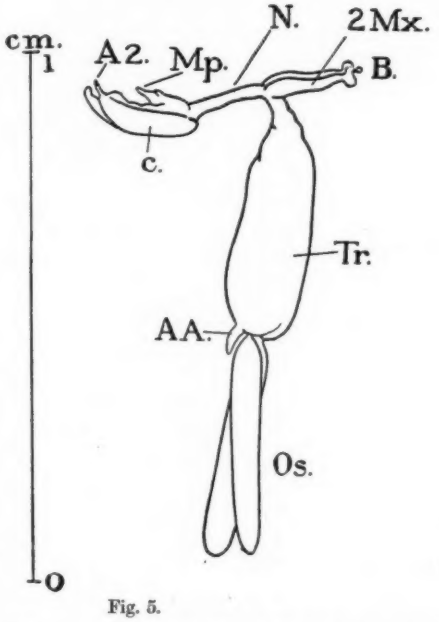

Fig. 5.

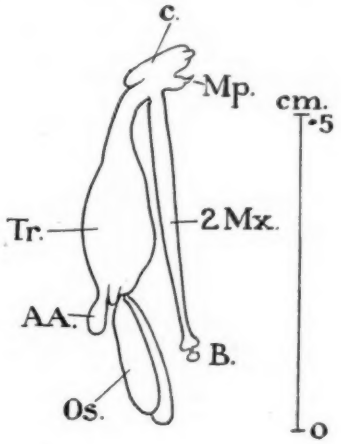

Fig. 6.

Fig. 5. *Charopinus dubius* ♀ in right lateral aspect. *A* 2. = antennae; *c* = cephalothorax; *Mp.* = maxillipedes; *N.* = cephalic neck; 2 *Mx.* = second maxilla; *B.* = bulla; *Tr.* = trunk; *AA.* = abdominal appendages; *Os.* = eggstrings.

Fig. 6. *Lernaeopodina cluthae* ♀. Lettering as in Fig. 5.

beetles, and diagonally truncated anteriorly. *Trunk* cylindrical, narrowed into a long, slender neck anteriorly, flattened dorsi-ventrally. *Abdominal appendages* minute. *Eggstrings* long, cylindrical, as long as trunk. *Second maxillae* short as compared with other species, tapering, expanded at the apices where they fuse and form a disc. *Bulla* chitinous, dark-brown, spherical.

Remarks. This animal was described by P. J. van Beneden (1851) as *Brachiella pastinacae* and as such is still labelled in the museum. Besides the characters of the male and the structure of the first antennae and the first

maxillae which cannot be detected in these specimens, it obviously cannot be placed in the genus *Brachiella* owing to the backward reflection of the cephalothorax, the enlarged ends of the second maxillae, and the abdominal appendages being dorsal in position to the eggstrings.

A Comparison of the four principal species of Charopinus.

Species... *Author...*	*dalmanni* Retzius	*dubius* T. Scott	*ramosus* Krøyer	*bicaudatus* Krøyer
Cephalothorax	Reflexed: parallel to trunk	At right angles to trunk	In same straight line as trunk	At right angles to trunk. Carapace present
Trunk	Sub-pyriform	Ovate	Long and narrow	Cylindrical
Abdominal appendages	Nearly as long as trunk. Strongly curved	Half as long as trunk	Minute	Minute
Second maxillae	Long, corrugated, tapering. Apices: semilunar discs, not coherent	Long, slender, tapering	Long, slender, not tapering. Apices coherent at inner edges; outer each with two long processes	Short, tapering. Apices coherent and expanded to form a disc
Bulla	? A cartilaginous plug	Canoe-shaped, well-marked manubrium	Stellate manubrium	Spherical

Genus **Lernaeopodina** Wilson (1915).

Generic Diagnosis. ♀. *Cephalothorax* at an oblique angle to the trunk. Dorsal carapace small and poorly defined. *Trunk* pear-shaped and narrowed posteriorly, the anterior portion narrowed into a distinct neck in which one or two segments (*L. similis*) can be differentiated. *Abdominal appendages* one pair dorsal to the *eggstrings* which are cylindrical, long and stout. *Second maxillae* long and slender. *Bulla* pateriform as in *Lernaeopoda*.

L. similis (T. and A. Scott 1913).

Material. 1 ♀, 1913. 9. 18. 462, on the gills of *Raia batis* from the Firth of Clyde, 1899, presented by T. and A. Scott.

Dimensions: head and neck 1·5 mm., trunk 5·5 mm., abdominal appendages 1·5 mm., eggstrings 5·5 mm., second maxillae 2·5 mm. (Fig. 2).

Diagnosis. *Cephalothorax* rounded dorsally, no dorsal carapace. *Neck* of two segments. *Trunk* cylindrical, clavate. *Abdominal appendages* small, about one-fifth length of trunk. *Eggstrings* as long as trunk. *Second maxillae* about half the length of trunk. *Bulla* wanting.

L. cluthae (T. Scott 1900).

Material. ♂♂ about two dozen, 1913. 18. 443–452, on the gills of *Raia fullonica* and *R. radiata* from the Northumberland Coast and the Irish Sea, presented by T. and A. Scott.

Dimensions: head and neck 1·25 mm., trunk 3·2 mm., abdominal appendages 0·7 mm., eggstrings 2 mm., second maxillae 4·8 mm. (Fig. 6).

Diagnosis. *Cephalothorax* flattened dorsally; a slight dorsal carapace. *Neck* not segmented. *Trunk* pyriform. *Abdominal appendages* small and stout. *Eggstrings* stout, shorter than trunk. *Second maxillae* extremely long, longer than trunk, straight with expanded apices. *Bulla* resembling that of *Lernaeopoda*. A very small species.

My thanks are due to Miss E. C. Humphreys for kindly executing the figures.

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ERRATUM.

Parasitology, **20**, 87. The legend to Fig. 7 should read:
A 1. = antennules; *A* 2. = antennae.

(*MS. received for publication* 24. v. 1928.—Ed.)

ON A COLLECTION OF NEMATODES FROM NIGERIAN MAMMALS (CHIEFLY RODENTS).

By H. A. BAYLIS, M.A., D.Sc.

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(With 25 Text-figures.)

The following report deals with a considerable collection of Nematodes made by Prof. A. S. Pearse, of Duke University, Durham, N.C., U.S.A., in various parts of Nigeria, and very kindly sent by him to the writer for study and determination.

As was to be expected, in view of the fact that many of the hosts had probably never before been examined from the point of view of their parasites, a large proportion of the Nematodes found prove to be new species. Three new genera are proposed for the reception of some of them.

An interesting feature of the collection is the considerable series of new species belonging to the genus *Heligmonella* Monnig, and to very closely related genera. Only one species of *Heligmonella* was previously known, viz. *H. spira* Monnig, from South Africa. This species occurs also in the same host in Nigeria, while seven new species have been distinguished among Prof. Pearse's material which seem to be referable to the same genus. Four species are referred to a new genus, *Heligmonina*, and one to another new genus, *Heligmonoides*. The species of these three genera tend to resemble each other so closely that some doubts were entertained as to the wisdom of separating them generically. However, it is believed that this step is justified by the slight but constant differences found in the bursa of the males. These three genera seem to constitute a group, within the subfamily Heligmosominae, characteristic of African rodents.

Advantage has been taken of the opportunity of adding some details to the description of *Protospirura muricola* Gedoelst, a species which appears to be very abundant in Nigerian rodents, and of clearing up the question of the validity of the species *Physaloptera dispar* v. Linstow.

The type material of all the new species described is in the British Museum (Natural History), to which it has been generously presented by Prof. Pearse.

The following is a list of the hosts. The writer is indebted to Mr M. A. C. Hinton for kindly supplying information as to their systematic positions.

Rodentia.

Family Muridae.

Subfamily Murinae.

Aenomys hypoxanthus
Arvicanthis mordax
Arvicanthis rufinus
Cricetomys buchanani
Cricetomys emini
Hybomys univittatus
Leggada musculoides
Lemniscomys striatus
Lophuromys sikapusi
Malacomys edwardesi
Mastomys erythroleucus
Mus musculus
Praomys tullbergi
Rattus rattus
Uranomys foxi

Subfamily Gerbillinae.

Taterillus gracilis angelus
Taterona kempi

Family Thryonomyidae (Hystricomorpha).

Thryonomys swinderianus

Family Sciuridae.

Euxerus erythropus moestus
Funisciurus anerythrus
Funisciurus auriculatus oliviae
Heliosciurus isabellinus
Protoxerus stangeri nigeriae

Lemuroidea.

Family Nycticebidae.

Perodicticus potto

Insectivora.

Family Erinaceidae.

Atelerix spiculus
Atelerix spinifex

Family Soricidae.

Crocidura manni
Crocidura sp.

Carnivora.

Family Viverridae.

Genetta tigrina pardina

Order **ASCAROIDEA**.

Family ASCARIDAE.

Subfamily Anisakinae.

Porrocaecum sp.

Larval forms of a species of *Porrocaecum* were collected on two occasions from shrews (*Crocidura* sp.) at Adu. The site mentioned in one case is the axilla, in the other the intestine. These larvae probably belong to one of the

species occurring, as adults, in birds of prey. A larval *Porrocaecum* also occurred in the axilla of *Hybomys univittatus* at Adu.

Family HETERAKIDAE.

Subfamily HETERAKINAE.

Heterakis spumosa Schneider, 1866.

This common and widely-distributed species occurs in the collection from the following hosts: *Cricetomys emini* (locality, Ife), *Cricetomys buchanani* (locality, Kano), and *Lophuromys sikapusi* (locality, Ibadan).

Subfamily SUBULURINAE.

Subulura boueti (Gendre, 1911) Travassos, 1913.

Heterakis boueti Gendre (1911), p. 74, figs. 1–6.

A pair of specimens obtained from *Lophuromys sikapusi* at Ife, and another pair from *Praomys tullbergi* at Adu, are referred to this species. The males have two spicules, instead of a single spicule as stated by Gendre. The specimens (mounted in glycerine-jelly) are too opaque for the accessory piece to be seen.

Family OXYURIDAE.

Subfamily OXYURINAE.

Syphacia pearsei, sp. n. (Fig. 1).

Host: *Heliosciurus isabellinus*.
Position: caecum.
Locality: Ase.

Length, male 1·9–2 mm., female 3·2–4 mm. Maximum thickness, male 0·13 mm. (exclusive of the ventral bosses), female 0·19–0·24 mm. Diameter of head (including cuticular expansion) 0·07 mm. in male, 0·07–0·11 mm. in female. Length of oesophagus, including bulb, male 0·34–0·36 mm., female 0·38–0·48 mm. Dimensions of bulb: in male, length 0·06–0·07 mm., width 0·07 mm.; in female, length 0·07–0·1 mm., width 0·08–0·11 mm. Cuticular striations, distance apart, in male 0·0075–0·01 mm.; in female 0·01–0·015 mm. Nerve-ring 0·14 mm. from anterior end in male, 0·15–0·17 mm. in female. Excretory pore 0·45 mm. from anterior end in male, 0·46–0·68 mm. in female.

Lateral alae extend throughout the greater part of the body, but end some distance in front of the anus in both sexes.

Caudal end of male with two ventral bosses in front of the cloaca, not three as in the genotype, *S. obvelata*. Tail of male 0·18–0·23 mm. long, rather more than two-thirds of this being accounted for by the slender terminal filament. Spicule about 0·13 mm. in length, accessory piece about 0·07 mm. The latter is apparently not barbed at the tip. Three pairs of caudal papillae present, two relatively small and adanal, the third larger and just in front of the terminal tail-filament.

Tail of female 0·7–0·85 mm. long, tapering throughout. Vulva 0·5–0·8 mm.

from anterior extremity. Eggs about 0·1 × 0·037 mm., relatively shorter and less banana-shaped than in *S. obvelata*.

This species appears to be rather closely related to *S. pallaryi* (Seurat, 1915), from *Xerus getulus*. It differs from it, however, in several of its measurements, and notably in the form and length of the tail in the male.

Syphacia nigeriana, sp. n. (Fig. 2).

Hosts: *Taterillus gracilis angelus* (Locality, Kano).
Taterona kempi. (Loc., Ibadan.)
Praomys tullbergi. (Loc., Adu.)
Mastomys erythroleucus. (Loc., Ife.)
(?) *Lemniscomys striatus*. (Loc., Adu.) (Females only.)

Position: intestine.

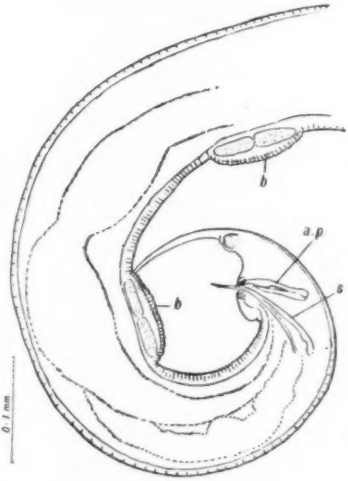

Fig. 1.

Fig. 2.

Fig. 1. *Syphacia pearsei*. Caudal end of male; lateral view. *a.p.* accessory piece; *b. b.* ventral bosses; *s.* spicule.

Fig. 2. *Syphacia nigeriana*. Caudal end of male; latera lview.

Length, male 1·2–1·45 mm., female (average) 5·3 mm. Maximum thickness, male 0·14 mm. (exclusive of ventral bosses), female 0·25–0·3 mm. Diameter of head (including cuticular expansion) 0·06 mm. in male, about 0·07 mm. in female. Length of oesophagus, including bulb, in male about 0·25 mm., in female 0·35–0·42 mm. Dimensions of bulb: in male, length and width 0·06 mm.; in female, 0·09–0·1 mm. Cuticular striations, distance apart (in middle region of body), in male about 0·0075 mm.; in female about 0·0125 mm. Nerve-ring about 0·12 mm. from anterior end in male, about 0·18 mm. in female. Excretory pore about 0·34 mm. in male, 0·6 mm. in female, from anterior end. Lateral alae very narrow.

Caudal end of male with three preanal ventral bosses, as in genotype. Posterior lip of cloaca produced into a projecting flap. Papillae as in the previous species. Tail 0·1–0·11 mm. long, fairly regularly tapering, with posterior pair of papillae somewhat in front of its middle. Spicule 0·095 mm. long, accessory piece 0·035 mm.

Tail of female 0·85–0·95 mm. long, tapering throughout. Vulva 0·7–0·8 mm. from anterior extremity. Eggs somewhat banana-shaped, 0·0113–0·0125 × 0·035–0·04 mm.

This species is very similar to *S. obvelata* (Rud.), the genotype, but differs from it notably in the much greater length of the tail in the female, and in other minor points.

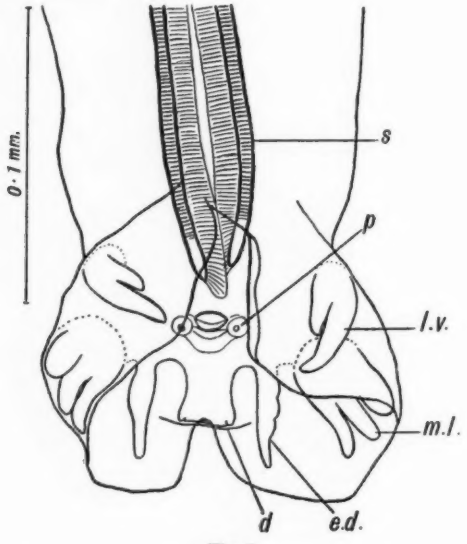

Fig. 3.

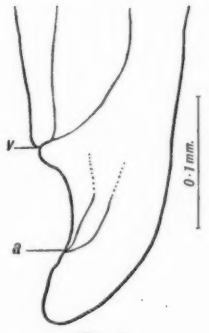

Fig. 4.

Fig. 3. *Parastrongylus tateronae.* Caudal end of male; ventral view. *d.* dorsal ray; *e.d.* externo-dorsal ray; *l.v.* latero-ventral ray; *m.l.* medio-lateral ray; *p.* papilla; *s.* spicules.

Fig. 4. *Parastrongylus tateronae.* Caudal end of female; lateral view. *a.* anus; *v.* vulva.

Order **STRONGYLOIDEA.**

Family METASTRONGYLIDAE.

Parastrongylus tateronae, n. g., sp. n. (Figs. 3 and 4).

Host: *Taterona kempi.*

Position: stomach, according to collector's label—normal habitat perhaps lungs or air-passages.

Locality: Ibadan.

Very fragile worms with thin, delicate cuticle. Length, male, 14–14·7 mm.; female 14·5–21 mm. Maximum thickness, male 0·25–0·3 mm.; female, 0·28–

0·34 mm. Mouth simple, without buccal capsule. Oesophagus simple, narrow, very slightly club-shaped posteriorly, 0·25 mm. long in male, 0·28 mm. in female. Intestine, at its origin, much wider than oesophagus.

Caudal end of male with moderately well developed bursa, turned ventrally at right angles to longitudinal axis of body, with lateral lobes separated by an indentation opposite to the dorsal ray. Dorsal ray short and broad. Externo-dorsal rays originating separately from it, longer and digitiform. Lateral rays originating in a common trunk, parallel and digitiform, the antero-lateral stouter than the others. Ventral rays widely separated from lateral rays, closely applied to each other, the ventro-ventral considerably shorter than the latero-ventral. A pair of sessile papillae present at the sides of the cloaca. Spicules equal, 0·5–0·62 mm. long, with broad ala on inner side, closely applied to each other distally, both shaft and ala with conspicuous transverse striations. No accessory piece or "telamon" observed, but dorsal wall of cloaca thickened and apparently chitinised.

Caudal end of female narrowed rather suddenly and slightly curved ventrally immediately behind the vulva, which is situated at 0·1–0·15 mm. from the extremity. Tail blunt, 0·05–0·06 mm. long. The uterus, in the specimens examined, contains oval, very thin-shelled eggs, measuring about 0·055–0·062 mm. × 0·037 mm.

This worm appears to be rather closely related to *Protostrongylus* Kamensky, 1905 (= *Synthetocaulus* Railliet and Henry, 1907), but differs from it in the absence of a "chitinoid arc" at the posterior extremity of the male, and of the accessory piece and "telamon."

Family TRICHOSTRONGYLIDAE.

Subfamily Trichostrongylinae.

Obeliscoides nigeriae, sp. n. (Fig. 5).

Host: *Cricetomys emini*.

Position: intestine.

Locality: Adu.

A single pair of specimens. Length, male 7 mm., female 11 mm. Maximum thickness, male 0·12 mm., female 0·13 mm. Cuticle with extremely fine transverse striations. No longitudinal ridges visible. Head without cuticular inflation, diameter in male 0·023 mm., in female 0·025 mm. Length of oesophagus 0·4 mm. in male, 0·48 mm. in female. Nerve-ring just in front of middle of oesophagus (0·23 mm. from anterior end in female).

Dorsal ray of male very long, with two short, bifurcate terminations and a pair of accessory branches originating at about the posterior sixth of the main stem. Externo-dorsal rays also originate from stem of dorsal ray at about its anterior third. Other characters of bursa much as described for *O. cuniculi* (Graybill, 1923), the genotype of *Obeliscoides*, except that there is no distinct dorsal lobe. Spicules approximately 0·2 mm. long, stout and longitudinally

ridged. It has not been possible to make out the form of their terminations.

Tail of female tapering and pointed, about 0·15 mm. long. Vulva a transverse slit at about 2 mm. from posterior extremity. Combined length of ovejectors about 0·7 mm.

Subfamily HELIGMOSOMINAE.

Heligmonella spira Monnig, 1927.

Monnig (1927), p. 263, Figs. 3–6.

This species, recorded by Monnig from the cane rat (*Thryonomys swinderianus*) near Pretoria, is represented in the present collection by specimens from the same host obtained at Odumayu, Nigeria.

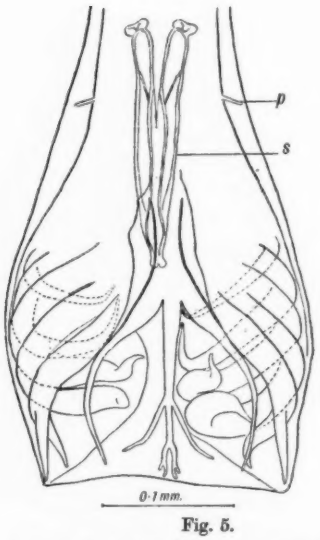

Fig. 5.

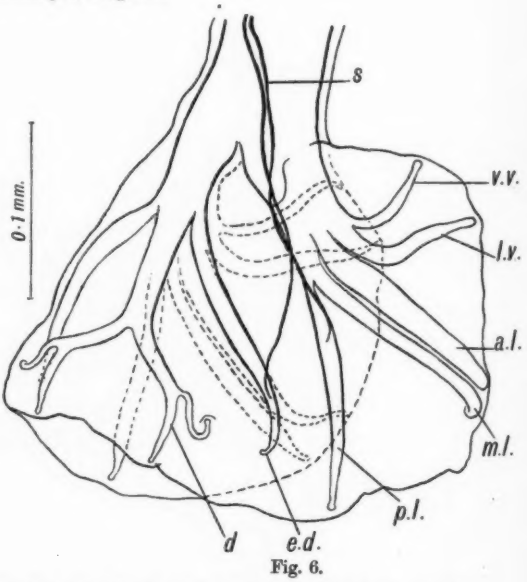

Fig. 6.

Fig. 5. *Obeliscoides nigeriae.* Caudal end of male; dorsa lview. *p.* prebursal papilla; *s.* spicules.
Fig. 6. *Heligmonella monnigi.* Bursa of male; latero-dorsal view. *a.l.* antero-lateral ray; *d.* dorsal ray; *e.d.* externo-dorsal ray; *l.v.* latero-ventral ray; *m.l.* medio-lateral ray; *p.l.* postero-lateral ray; *s.* spicules; *v.v.* ventro-ventral ray.

Heligmonella monnigi, sp. n. (Fig. 6).

Host: *Praomys tullbergi.* What is probably the same species occurred also in *Malacomys edwardesi*, and two males, according to the label, from *Cricetomys emini.* These last specimens were received in spirit, while the mounted specimens bearing the same number belonged to a different species. It is rather doubtful, therefore, whether *Cricetomys emini* should be included among the hosts of *H. monnigi.*

Position: intestine (occasionally stomach).
Locality: Adu.

Length, male 3·5–4·2 mm., female 3·4–5·3 mm. Maximum thickness, male 0·1–0·13 mm., female 0·15–0·17 mm. Head with very slight cuticular inflation, diameter about 0·03 mm. Oesophagus 0·4–0·47 mm. long. Cuticle of body with about 10–12 moderately high longitudinal ridges.

Bursa of male with symmetrical lateral lobes. Terminal branches of dorsal ray widely divergent, bidigitate, with the outer termination turning forwards. Spicules very slender, about 1 mm. long.

Tail of female 0·037–0·043 mm. long. Vulva 0·1–0·113 mm. from posterior end. Cuticle in mature female much inflated on dorsal side for some distance in front of vulva, and forming at level of vulva a slight prepuce-like fold running round the body.

Heligmonella impudica, sp. n. (Fig. 7).

Hosts: *Taterona kempi*. (Locality, Ibadan.)
Lemniscomys striatus. (Loc., Adu, Oyo.)
Arvicanthis mordax. (Loc., Kano.)
? *Arvicanthis rufinus*. (Loc., Ibadan.)

Position: intestine.

Length, male 3·8–4·9 mm., female 6·8–9·2 mm. Maximum thickness, male 0·1–0·13 mm., female 0·14–0·18 mm. Diameter of cuticular inflation of head about 0·04–0·05 mm. Oesophagus 0·035–0·045 mm. long. Cuticle of body with about 10–12 longitudinal ridges. These are not very high, except on the sides, where they form a pair of fairly well developed alae.

Bursa of male with symmetrical lateral lobes. Terminal branches of dorsal ray fairly widely divergent, bidigitate, the outer termination turning outwards and slightly forwards. Spicules 0·27–0·36 mm. long, very slender (not more than about 2·5 μ thick).

Tail of female about 0·075 mm. long. Vulva about 0·15 mm. from posterior end. Caudal end sometimes bent ventrally into a hook just behind the vulva. No prevulvar cuticular inflation.

Heligmonella affinis, sp. n.

Host: *Mastomys erythroleucus*.
Position: intestine.
Localities: Adu, Oyo.

Length, male 2·65–3·2 mm., female 3·4–3·5 mm. Maximum thickness, male 0·08–0·09 mm., female 0·09–0·1 mm. Head with very slight cuticular inflation, about 0·02–0·025 mm. in diameter. Oesophagus about 0·35–0·4 mm. long. Cuticle of body with about 10–12 slight longitudinal ridges.

Bursa of male with dorsal and externo-dorsal rays similar to those of *H. impudica*, but relatively stouter. Spicules about 0·4 mm. long, rather stout (about 4–5 μ wide, including the alae), brownish.

Tail of female about 0·05 mm. long. Vulva about 0·12 mm. from posterior end. Caudal end sometimes hooked ventrally. The body may be slightly swollen in front of the vulva, but there is no cuticular fold.

Heligmonella gracilis, sp. n. (Fig. 8).

Host: *Leggada musculoides*.
Position: intestine.
Locality: Ibadan.

Length, male 2·7–3·27 mm., female (a single specimen) 3·9 mm. Maximum thickness, male about 0·07 mm., female 0·1 mm. Head with well-developed cuticular inflation, 0·028–0·038 mm. in diameter. Oesophagus 0·31–0·32 mm. long. Cuticle of body with about 16 moderately developed longitudinal ridges.

Bursa of male with symmetrical lateral lobes and slender rays. Branches of dorsal ray widely divergent and each with two slender, straight, divergent terminal digitations. Spicules 0·23–0·28 mm. long.

Tail of female about 0·052 mm. long. Vulva about 0·15 mm. from posterior end. Cuticle somewhat inflated dorsally in front of vulva, but not forming a prepuce-like fold.

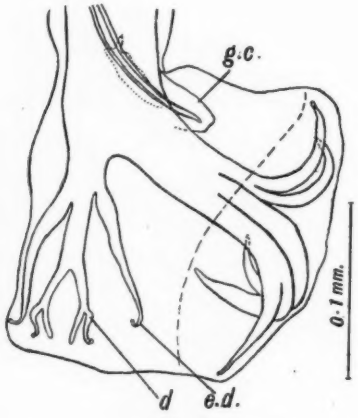

Fig. 7.

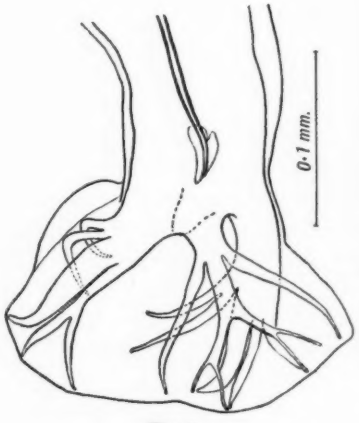

Fig. 8.

Fig. 7. *Heligmonella impudica*. Bursa of male; latero-dorsal view (only right lateral lobe shown). *d*. dorsal ray; *e.d.* externo-dorsal ray; *g.c.* genital cone.
Fig. 8. *Heligmonella gracilis*. Bursa of male; latero-dorsal view.

Heligmonella streptocerca, sp. n. (Fig. 9).

Host: *Funisciurus anerythrus*.
Position: intestine.
Localities: Okoya, Olorishako, Ife, Onitiri.

Length, male 6·1–6·5 mm., female 7·3–8 mm. Maximum thickness, male 0·15–0·18 mm., female about 0·19 mm. Anterior end of body almost invariably

forms 1–1½ turns of a spiral. Cuticular inflation of head well developed, 0·05–0·06 mm. in diameter, marked off behind by a constriction. Oesophagus about 0·4–0·5 mm. long. Cuticle with conspicuous transverse striations and with 12–14 longitudinal ridges, not very prominent except in the cervical region, where they form fairly broad alae laterally.

Bursa of male with rays of right lobe rather longer than those of left lobe. Dorsal ray with short terminal branches, rather close together, and each with two almost parallel digitations. Externo-dorsal rays slender. Spicules 0·45–0·49 mm. long, relatively stout.

Tail of female about 0·055 mm. long. Caudal end forms 1–1½ turns of a spiral immediately behind the vulva.

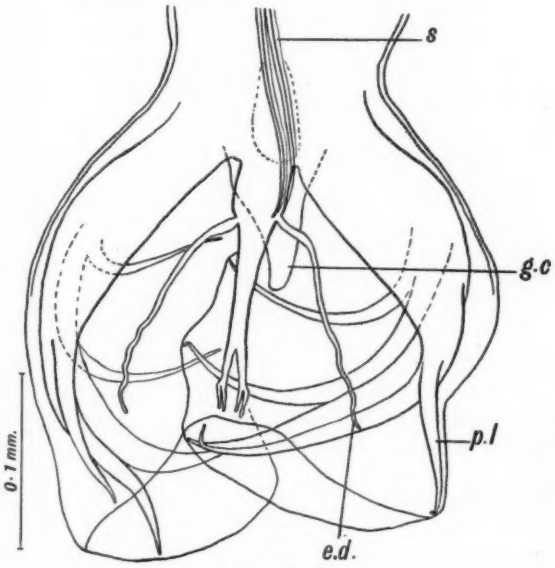

Fig. 9.

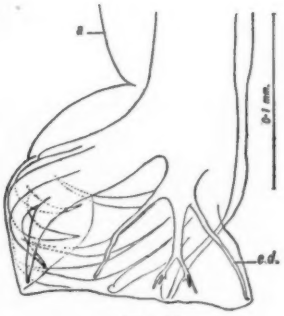

Fig. 10.

Fig. 9. *Heligmonella streptocerca.* Bursa of male; dorsal view. *e.d.* externo-dorsal ray; *g.c.* genital cone; *p.l.* postero-lateral ray; *s.* spicules.

Fig. 10. *Heligmonella trifurcata.* Bursa of male; latero-dorsal view. *a.* left ala; *e.d.* externo-dorsal ray.

Heligmonella trifurcata, sp. n. (Fig. 10).

Host: *Funisciurus anerythrus.*

Position: intestine.

Localities: Adu, Okoya.

Length, male 3·6–4 mm., female 3·7–3·95 mm. Cuticle of head with well-developed inflation, 0·035–0·045 mm. in diameter and limited behind by a constriction. Cuticle of body with about 12 longitudinal ridges. Two of these

form broad lateral alae. Left ala broader than right, and much more highly developed in male than in female. Maximum width of male, including left ala, about 0·1–0·12 mm.; without left ala, 0·06–0·09 mm. Maximum width of female 0·09–0·1 mm. Length of oesophagus about 0·35 mm.

Bursa of male with rays of right lobe much longer than those of left lobe. Branches of dorsal ray divergent, each with three terminations owing to the formation of a short spur on the inner side of its inner digitation. Spicules comparatively stout, about 0·3 mm. long.

Tail of female 0·03–0·035 mm. long. Vulva 0·08–0·09 mm. from posterior end. No prevulvar cuticular inflation.

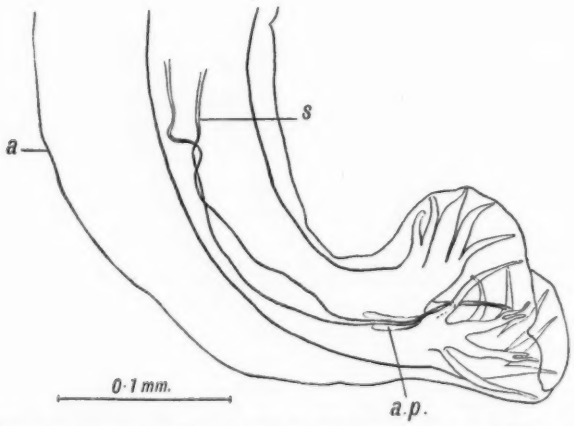

Fig. 11. *Heligmonella intermedia.* Caudal end of male; dorsal view. *a.* left ala; *a.p.* accessory piece; *s.* spicules.

Heligmonella intermedia, sp. n. (Fig. 11).

Host: *Lemniscomys striatus.*

Position: intestine.

Localities: Adu, Ibadan.

Length, male 2·35–2·7 mm., female 2·9–3·3 mm. Diameter of head about 0·03 mm. Cuticle with about 12–14 longitudinal ridges. One of these, in the male, developed into an extremely broad left lateral ala. In the female, this ala is much less highly developed. Maximum width of male, including left ala, 0·12–0·15 mm.; without left ala, 0·07–0·08 mm. Maximum width of female about 0·13 mm. Length of oesophagus about 0·3 mm.

Bursa of male with symmetrical lobes. Branches of dorsal ray stout and as long as, or longer than, its main stem, each with two almost parallel digitations of which the outer is the longer. Spicules very slender except at their roots, about 0·3 mm. long.

Tail of female about 0·075 mm. long, rather slender and tapering. Vulva about 0·137 mm. from posterior end. No prevulvar cuticular inflation.

The genus **Heligmonella** Monnig, 1927.

In view of the foregoing series of new species, the diagnosis of this genus given by Monnig (1927, p. 264) requires some slight modifications, as follows:

Heligmosominae. Body red when fresh, sometimes spirally coiled. Cuticle with well-marked longitudinal ridges on which the transverse striations are more conspicuous than elsewhere. Two of these ridges may be more highly developed than the others, and form a pair of lateral alae, of which the left, especially in the male, may be much broader than the right. Cephalic cuticle inflated and transversely striated.

Male: bursa with lateral lobes symmetrical or asymmetrical. In the latter case the rays of the right lobe are longer than those of the left. Ventral rays divergent. Medio-lateral and postero-lateral rays originating from a common trunk, but divergent distally. Antero-lateral usually stouter than the other lateral rays. Externo-dorsal rays originating from the main stem of the dorsal ray at some distance from its base. Dorsal ray bifurcate distally, the branches being bi- or tridigitate. Spicules usually slender, alate. An accessory piece present.

Female: vulva near anus, sometimes preceded by a region where the cuticle of the body, especially dorsally, is inflated, and may form a prepuce-like fold.

Parasitic in the intestine or stomach of rodents.

Genotype: *H. spira* Monnig, 1927.

The last species described above (*H. intermedia*) is in some respects a connecting-link between *Heligmonella* and the next genus to be described. In that form the male has a symmetrical bursa, but also shows the extreme development of the left ala which is characteristic of the following genus.

Heligmonina, n.g.

Diagnosis. Heligmosominae. Closely related to *Heligmonella*, but with the left ala enormously developed in both sexes and sometimes as wide as, or wider than, the body proper. Right ala much narrower. Longitudinal ridges (similar to those of *Heligmonella*) present on the cuticle dorsally and ventrally. Body frequently forms a corkscrew-like spiral.

Male: bursa with asymmetrical lateral lobes, the left lobe considerably larger and with much longer rays than the right. Genital cone prominent. Dorsal ray with branches as long as, or longer than, its main stem, and sometimes asymmetrical. Externo-dorsal rays originate at the base of the stem of the dorsal ray, or separately from it. Other rays, spicules and accessory piece as in *Heligmonella*.

Female: apart from the great development of the left lateral ala, similar to that of *Heligmonella*. Cuticle sometimes much inflated, especially dorsally, in prevulvar region in mature females.

Genotype: *H. praomyos*, sp. n.

Heligmonina praomyos, sp. n. (Fig. 12).

Hosts: *Praomys tullbergi.*
? *Malacomys edwardesi* (females only).

Position: intestine.

Locality: Adu.

Length, male 2·1–2·6 mm., female about 3·2 mm. Maximum width, including left ala, 0·15–0·19 mm.; without left ala, 0·06–0·1 mm. Diameter of head 0·02–0·03 mm. Oesophagus apparently about 0·2–0·25 mm. long. Cuticle with about 12 slight longitudinal ridges in addition to the lateral alae.

Bursa of male with rays of left lobe considerably longer than those of right lobe. Dorsal ray asymmetrical, with left branch much stouter than right. The outer of the two terminations of each branch turns forwards. Externo-dorsal

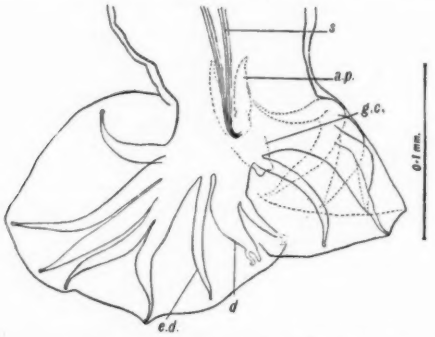

Fig. 12. *Heligmonina praomyos.* Bursa of male; dorsal view. *a.p.* accessory piece; *d.* dorsal ray; *e.d.* externo-dorsal ray; *g.c.* genital cone; *s.* spicules.

rays originate at the sides of the base of the dorsal ray, apparently separately from it. Spicules 0·33–0·35 mm. long.

Tail of female about 0·037 mm. long. Vulva about 0·2 mm. from posterior end.

Heligmonina cricetomyos, sp. n. (Fig. 13).

Hosts: *Cricetomys emini.* (Localities, Adu, Ife.)
Cricetomys buchanani. (Loc., Kano.)

Position: intestine.

Length, male 5–5·35 mm., female 6·5–7·6 mm. Maximum width, including left ala, 0·2–0·32 mm.; without left ala, 0·12–0·17 mm. Diameter of head 0·03–0·04 mm. Length of oesophagus 0·3–0·4 mm. Cuticle with about 8–10 inconspicuous longitudinal ridges in addition to the lateral alae.

Bursa of male with left lobe enormously larger than right lobe, and with the rays of that side very much more highly developed. Dorsal ray with symmetrical branches, each with two almost parallel terminations. Left externo-

dorsal ray originates from the stem of the dorsal ray near its base, right externo-dorsal ray originates independently. Spicules 0·4–0·45 mm. long.

Tail of female blunt, about 0·04 mm. long. Vulva about 0·2 mm. from posterior end. Cuticle sometimes much inflated in front of vulva.

Heligmonina aenomyos, sp. n.

Host: *Aenomys hypoxanthus*.

Position: intestine.

Locality: Ife.

Length, male 3·2–3·6 mm., female 3·4–4·6 mm. Maximum width, including left ala, male about 0·18 mm., female about 0·16 mm.; without left

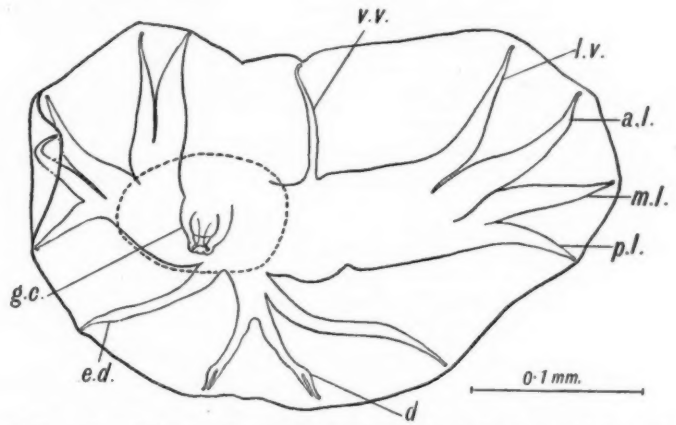

Fig. 13. *Heligmonina cricetomyos.* Bursa of male, cut off and spread out; ventral view. *a.l.* antero-lateral ray; *d.* dorsal ray; *e.d.* externo-dorsal ray; *g.c.* genital cone; *l.v.* latero-ventral ray; *m.l.* medio-lateral ray; *p.l.* postero-lateral ray; *v.v.* ventro-ventral ray.

ala, male about 0·1 mm., female 0·11–0·12 mm. Head with fairly well developed cuticular inflation, about 0·025–0·033 mm. in diameter. Oesophagus about 0·32 mm. long. Cuticle with about 12 slight longitudinal ridges in addition to the lateral alae.

The bursa, in the three males available, is in too poor a condition for its characters to be made out. Spicules about 0·5 mm. long.

Tail of female about 0·055 mm. long. Vulva about 0·22 mm. from posterior end. The posterior end of the body is generally bent ventrally almost at a right angle about half-way between the vulva and anus, while in the older females the cuticle is much inflated dorsally in the vulvar region, and filled with a granular mass.

Heligmonina magna, sp. n. (Fig. 14).

Host: *Protoxerus stangeri nigeriae.*

Position: intestine.

Locality: Ife.

One male and two females available for examination. Length, male about 12 mm., females 18 and 19·4 mm. Maximum width, including left ala, male about 0·23 mm., female 0·3 mm.; without left ala (female) 0·2 mm. Head with well-developed cuticular inflation, 0·06–0·07 mm. in diameter. Cuticle with 20–24 low, but distinct, longitudinal ridges in addition to the lateral alae.

Bursa of male extremely asymmetrical, with very long left lobe and rays, and very short right lobe and rays. Dorsal ray with symmetrical, long, slender branches, whose terminations cannot be made out with certainty in the single specimen available, but appear to be simple. Externo-dorsal rays originate at the base of the dorsal ray. Spicules 0·75 mm. long.

Caudal end of female completely or almost completely hidden by a swollen, prepuce-like cuticular sheath.

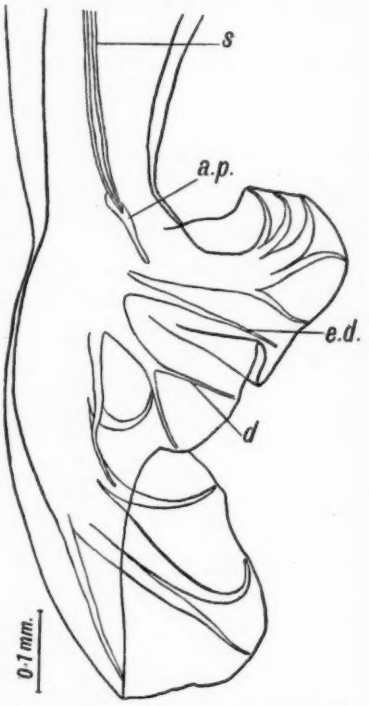

Fig. 14. *Heligmonina magna.* Bursa of male; dorsal view. *a.p.* accessory piece; *d.* dorsal ray; *e.d.* externo-dorsal ray; *s.* spicules.

Heligmonoides, n.g.

Diagnosis. Heligmosominae. Closely related to *Heligmonella*, but with left lobe of bursa in male larger than right lobe. Dorsal ray with branches about as long as its stem, and externo-dorsal rays originating from it at the level of its bifurcation.

Heligmonoides murina, sp. n. (Figs. 15 and 16).

Hosts: *Leggada musculoides.* (Localities: Adu, Ibadan.)
Mus musculus. (Loc., Adu).

Position: intestine.

Length, male 3·1–3·7 mm., female 4·2–4·45 mm. Maximum thickness, male 0·045–0·08 mm., female 0·1–0·12 mm. Cuticular inflation of head not very large, 0·017–0·02 mm. in diameter in male, 0·03 mm. in female. Length of oesophagus 0·26–0·34 mm. Cuticle with about 30 longitudinal ridges, which are not very prominent except near the anterior end, where they are wavy.

Bursa of male with the characters described above for the genus. Tips of branches of dorsal ray bidigitate. Spicules 0·87–0·89 mm. long.

Posterior end of female considerably thickened and strongly curled ventrally. Cuticle sometimes inflated and forming a slight prepuce-like fold at the level of the vulva. Tail about 0·025 mm. long. Vulva about 0·075 mm. from posterior end.

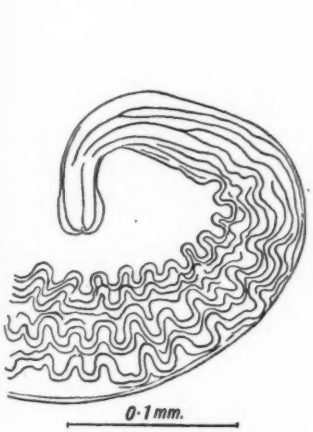

Fig. 15.

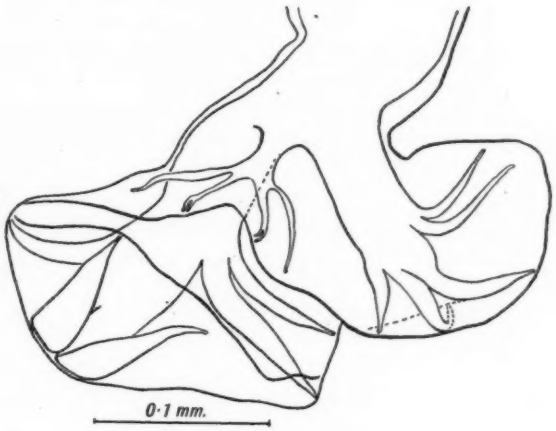

Fig. 16.

Fig. 15. *Heligmonoides murina.* Anterior end of female, showing the longitudinal cuticular ridges.
Fig. 16. *Heligmonoides murina.* Bursa of male; latero-dorsal view.

Order **FILARIOIDEA.**

Family FILARIIDAE.

Subfamily FILARIINAE.

Dirofilaria genettae, sp. n. (Fig. 17).

Host: *Genetta tigrina pardina.*

Position: not mentioned (presumably connective tissue).

Locality: Okoya.

Length, male 44–49 mm., female 110–115 mm. Maximum thickness, male about 0·3–0·32 mm., female 0·4–0·43 mm. Posterior end of body, in both sexes, more slender than anterior end. Caudal end of male coiled ventrally in a loose spiral. That of female gently curved dorsally. Cuticular striations very fine. Anterior extremity rounded, with inconspicuous papillae (apparently two simple lateral papillae and four double submedian papillae, the two small terminations of the latter situated one behind the other). Length of oesophagus 0·85 mm. in male, 0·9–1·1 mm. in female. Nerve-ring at 0·23 mm. in male, 0·27 mm. in female, from anterior end.

Tail of male about 0·06 mm. long, bluntly rounded. Four pairs of sublateral

preanal papillae with club-shaped peduncles, decreasing in size posteriorly. On the tail three pairs of similar, but smaller, sublateral papillae and two or three pairs of very minute subventral papillae. Left spicule 0·49 mm. long, with proximal half tubular, distal half with slender shaft and delicate alae. Right spicule stout, 0·18–0·19 mm. long, with rounded tip and expanded root.

Tail of female extremely short (0·06–0·07 mm.) and bluntly rounded. Anus a minute pore. Vulva a small pore situated at 1·8–2·1 from the anterior end, opening through a subglobular "sphincter" with very narrow lumen into a long, coiled vagina.

In some respects (notably in the dimensions of the spicules) this form seems to be very similar to *D. repens* Railliet and Henry, 1911, from the dog. It is, however, rather smaller and more slender, the vulva is situated rather further from the anterior end, and the number and arrangement of the caudal papillae are different from those described by Railliet and Henry.

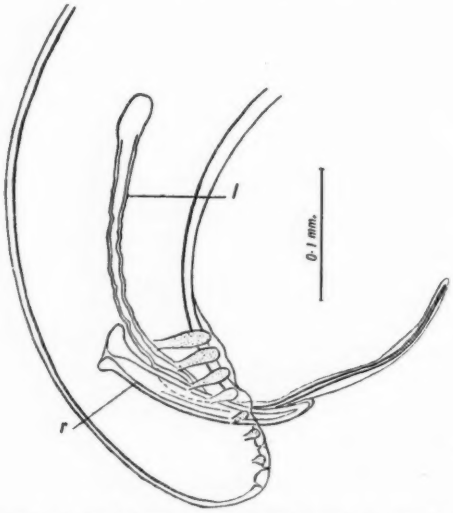

Fig. 17. *Dirofilaria genettae.* Caudal end of male; lateral view. *l.* left spicule; *r.* right spicule.

Family SPIRURIDAE.

Subfamily SPIRURINAE.

Protospirura muris (Gmelin, 1790).

A pair of specimens obtained from *Leggada musculoides* at Ibadan are referred to this species. It is somewhat remarkable that this common European parasite of rats and mice is apparently rare in Nigeria, while the closely-related form next to be dealt with is so abundant and occurs in so large a variety of hosts.

Protospirura muricola Gedoelst, 1916. (Figs. 18–20).

Gedoelst (1916), p. 57, Fig. 18.

This is probably the commonest Nematode parasite of rodents in Nigeria. It is represented by a very large number of specimens in the present collection, the hosts from which it was collected including:

Praomys tullbergi, Hybomys univittatus, Malacomys edwardesi, Rattus rattus, Mus musculus, Leggada musculoides, Cricetomys emini, Lemniscomys striatus, Mastomys erythroleucus, Uranomys foxi, Arvicanthis rufinus, Taterona kempi, Funisciurus auriculatus oliviae, F. anerythrus, Heliosciurus isabellinus and *Euxerus erythropus moestus.* What appears to be the same species also occurred in the Lemuroid *Perodicticus potto.*

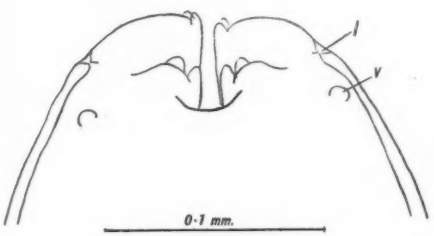

Fig. 18.

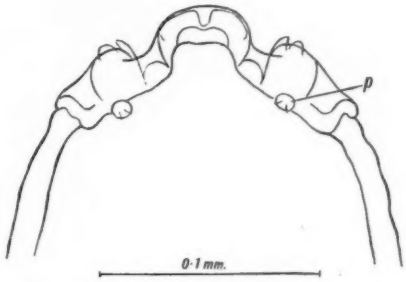

Fig. 19.

Fig. 18. *Protospirura muricola.* Anterior end of female; ventral view. *l.* lateral papilla; *v.* subventral papilla.

Fig. 19. *Protospirura muricola.* Anterior end of female; lateral view. *p.* submedian papilla.

P. muricola was described by Gedoelst on the basis of a single female, and a male of which the anterior end was missing, obtained from an undetermined rat (possibly *Cricetomys gambianus*) at Kivu, Belgian Congo. It inhabits the stomach, and occasionally the intestine, of its hosts.

Gedoelst's specimens appear to have been above the average size. He gives the length of the male as at least 31 mm., and that of the female as 50 mm. In the present collection from Nigeria the average length of the adult males is about 15–20 mm., and they rarely, if ever, exceed 25 mm. The females average 20–30 mm. in length, but are occasionally of about the size given by Gedoelst. In maximum thickness the males measure 0·45–0·75 mm., the females 0·9–1·2 mm. The entire oesophagus (measured from the anterior extremity of the lips) is 3·1–3·9 mm. long in the male, 4–6 mm. in the female. The distance from the anterior extremity to the posterior end of the laterally compressed pharynx is, in both sexes, 0·13–0·16 mm. The distance from the same point to the end of the anterior (muscular) portion of the oesophagus is 0·4–0·55 mm. The nerve-ring is situated at 0·33–0·4 mm., the cervical papillae at 0·31–0·32 mm., and the excretory pore at 0·44–0·6 mm., from the anterior end.

The lips are of the form indicated in Figs. 18 and 19. Each is composed of a lateral and two smaller submedian lobes, the latter having cuticular expansions externally, which are prominent in lateral view but are not seen at all in dorso-ventral view. On the inner face of each lobe there is a pair of flattened cuticular plates or flanges, but the teeth characteristic of *P. muris* and other species are absent. The caudal papillae of the male are as described by Gedoelst, except that there is an extra pair of small sublateral papillae almost at the tip of the tail. There are thus four pairs of preanal and six pairs of postanal papillae, most of which are very prominent and button-like. The spicules are very characteristic. The left spicule measures 0·43–0·52 mm. in length. When extruded (Fig. 20, *l.*) it is seen to be composed of a granular, dark-coloured central portion and a pair of extremely broad, delicate, membranous alar expansions.

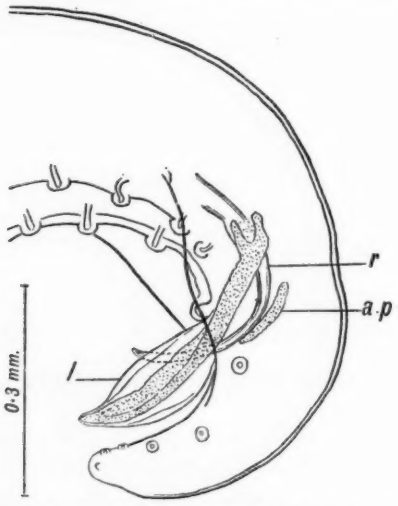

Fig. 20. *Protospirura muricola.* Caudal end of male; lateral view. *a.p.* accessory piece; *l.* left spicule; *r.* right spicule.

The right spicule is shorter (0·35–0·4 mm.), and of simpler form, being tubular and somewhat widened in diameter towards its base. The accessory piece is broad and flattened as seen in dorso-ventral view. The average dimensions of the eggs are 0·05 × 0·037 mm.

Subfamily Arduenninae.

Physocephalus sexalatus (Molin, 1860).

Two female specimens which appear to belong to this species were obtained from the stomach and intestine of *Cricetomys emini* at Adu. This parasite, normally occurring in swine, appears to have a wide range of occasional or accidental hosts, including the tapir, donkey, camel and ox, but does not seem to have been previously recorded from a rodent.

Physaloptera dispar v. Linst., 1904.

Von Linstow (1904) p. 380; Figs. 1 and 2.

Seurat (1917), p. 211; Fig. 1 (*P. clausa*).

This species occurs in the collection from the stomachs of two species of hedgehogs, *Atelerix spiculus* and *A. spinifex*. Seurat (1917) has given a careful description of the same form, under the name of *P. clausa*, of which he regarded *P. dispar* as a synonym, from *Erinaceus algirus* and *E. deserti* in Algeria. Ortlepp (1923) rightly considers Seurat's form as distinct from *P. clausa* Rud., 1819, of which he has re-examined the types. He suggests, however, that Seurat was wrong in identifying his Algerian material with *P. dispar*. This opinion is based on a comparison of v. Linstow's description with that of Seurat, and the author considers that "until von Linstow's specimens have been re-examined, his and Seurat's specimens must be treated as separate species."

The type-specimens of *P. dispar* v. Linstow, from *Erinaceus albiventris* (Nigeria), are in the British Museum (Natural History), and the writer has re-examined them, with the result that they are found to agree in every important respect with the description of "*P. clausa*" given by Seurat (1917). Von Linstow's description and figures are inaccurate in several particulars. The external "tooth" of each lip is blunt and papilla-like, but not squarely truncate as indicated by v. Linstow. The two "kleine Papillen" close to it, one on each side, are simply the tips of two of the three internal teeth, projecting at its sides. In his figure of the caudal end of the male, v. Linstow shows the small, median, precloacal papilla, which is sometimes hard to detect, but omits the large and conspicuous pair of pedunculate papillae figured by Seurat between this and the bases of the second pair of lateral papillae. These are, however, present in his types as well as in the material from *Atelerix*. The second and third pairs of papillae from the caudal extremity are figured by both authors, but Seurat, who calls the second pair "caudal pores," has correctly shown them as smaller than the third and rather inconspicuous. Seurat's figure somewhat exaggerates the length of the peduncles of the fourth pair of papillae from the posterior end.

There is some discrepancy between the two authors' descriptions in regard to the lengths of the spicules. Von Linstow gives that of the left spicule as 0·62 mm. and that of the right as 0·35 mm. According to Seurat, the left spicule varies in length from 0·275 to 0·36 mm., the right from 0·3 to 0·325 mm. In the specimens seen by the writer the average length of the right spicule is about 0·3 mm., and it has the terminal cap mentioned by Seurat, though this is perhaps rather conical than thimble-shaped ("en forme de dé"). The length of the left spicule varies considerably, ranging from about 0·3 to 0·5 mm., and its precise limits are sometimes difficult to determine in cleared specimens, so that it is possible either that it may occasionally reach the length given by

v. Linstow, or that this author overestimated its length in the particular specimen before him.

The uterus of the female is of the two-branched type, as described by Seurat.

It may be mentioned here that some specimens obtained by Mr A. Loveridge some years ago from *Atelerix hindei sotikae* at Singida, Tanganyika Territory, and determined by the present writer as *Physaloptera clausa* (see Loveridge, 1924, p. 696) appear to belong rather to *P. dispar*.

Physaloptera aduensis, sp. n. (Fig. 21).

Host: *Hybomys univittatus*.

Position: stomach and intestine.

Locality: Adu.

This species is represented by a considerable number of specimens, and was collected on twelve occasions from *Hybomys*[1].

Length, male 9–14 mm., female 13–20 mm. Maximum thickness, male about 0·65–0·8 mm., female about 0·8–1·2 mm. Lips rounded, apparently without "external tooth," but with three relatively large internal teeth. These are very blunt. Length of oesophagus, up to 3 mm. in male, up to 4 mm. in female.

Tail of male about 1·4 mm. long. Caudal papillae arranged as indicated in Fig. 21. Left spicule 0·8–1·7 mm. long. Right spicule stouter, 0·32–0·54 mm. long.

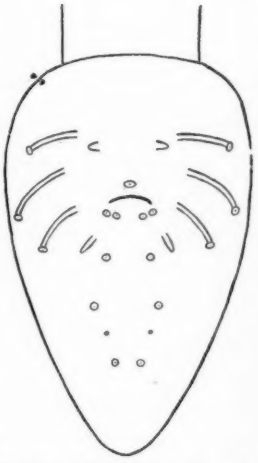

Fig. 21. *Physaloptera aduensis*. Diagram of caudal papillae of male (ventral view).

Tail of female short and blunt, generally covered by a prepuce-like cuticular sheath. Vulva somewhat in front of posterior end of oesophagus. The arrangement of the female genital organs could only be determined by dissection. Two females were dissected. In one the muscular vagina was 1·1 mm. long, and the "common trunk" of the uterus (including the "egg-chamber" of Ortlepp) about 0·95 mm. In the other the vagina was 2·1 mm. long and the "common trunk" 1·25 mm. There is a sharp bend at the point where the vagina joins the "egg-chamber." In one specimen the common trunk gave off posteriorly three branches, each of which divided again into two, so that there

[1] All the specimens had been mounted in glycerine-jelly, and in order to examine them adequately it was necessary to unmount them and re-clear in creosote or lactophenol. This process resulted in the cuticle becoming rather fragile, and it was found necessary to handle the material with unusual caution. For this reason it was found impracticable to obtain a camera-lucida drawing showing all the caudal papillae of the male, and the accompanying figure is a composite diagram.

were six uterine branches. This is probably the normal arrangement. In the other specimen one of the three primary branches gave off three, instead of two, secondary branches, making seven uterine branches altogether. The eggs measure about 0·055–0·06 mm. × 0·037–0·04 mm.

Subfamily THELAZIINAE (?).

Rictularia taterilli, sp. n. (Figs. 22–24). .

Host: *Taterillus gracilis angelus*.

Position: stomach and intestine.

Locality: Kano.

Of this species the collection contains one male and several females, obtained on four different occasions.

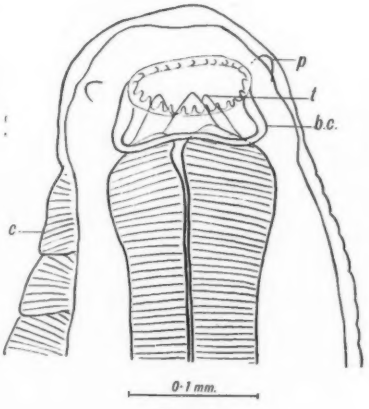

Fig. 22.

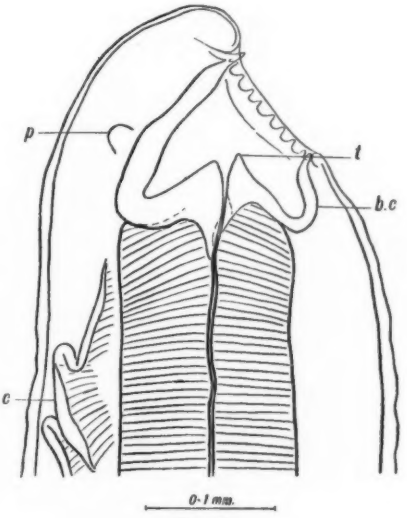

Fig. 23.

Fig. 22. *Rictularia taterilli*. Anterior end of female; dorsal view. *b.c.* buccal capsule; *c.* "combs"; *p.* lateral papilla; *t.* tooth.

Fig. 23. *Rictularia taterilli*. Anterior end of female; lateral view. *b.c.* buccal capsule; *c.* "combs"; *p.* lateral papilla; *t.* tooth.

Length, male 2·7 mm., female up to about 40 mm. Maximum thickness (excluding the "combs"), male about 0·25 mm., female about 0·7 mm. Cuticular striations in male fine (about 5 μ apart), in female coarse and rather irregular (about 50 μ apart). Male with 63 pairs of subventral "combs," extending throughout almost the whole length of the body, and four median ventral "combs" in front of the cloaca. Female with 40–41 pairs of prevulvar "combs" and 15–18 pairs of postvulvar "combs," the latter becoming more spine-like posteriorly.

Dorso-ventral diameter of head about 0·06 mm. in male, about 0·22 mm. in female. Buccal capsule: greatest length (outside) in male about 0·04 mm., in female about 0·16 mm.; greatest width (outside) in male about 0·047 mm., in female about 0·17 mm. Three large, conical teeth present at base of buccal capsule, and a series of small denticles at its opening. Distance from anterior extremity to posterior end of oesophagus 0·75 mm. in male, up to 3·8 mm. in female; from anterior extremity to end of anterior portion of oesophagus about 0·2 mm. in male, 0·8–0·9 mm. in female. Nerve-ring at 0·4–0·55 mm. from anterior end in female.

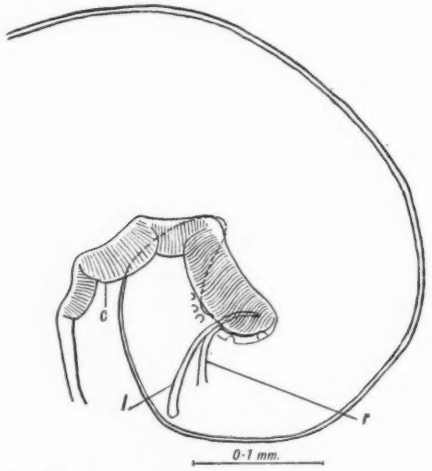

Fig. 24. *Rictularia taterilli.* Caudal end of male; lateral view. *c.* median ventral "combs"; *l.* left spicule; *r.* right spicule.

Tail of male about 0·11 mm. long. Of the caudal papillae (Fig. 24) all that could be made out were two pairs of preanal and three pairs of postanal. Left spicule about 0·12 mm. long, right spicule about 0·05 mm. These measurements are a little uncertain, the spicules, in the single (mounted) male available, being perhaps somewhat foreshortened.

Tail of female about 0·4 mm. long, blunt, but ending in a minute spike. Vulva 0·7–1 mm. in front of posterior end of oesophagus. Eggs roundish-oval, measuring about 0·05 mm. × 0·04 mm.

Order **TRICHINELLOIDEA.**

Family TRICHINELLIDAE.

Subfamily Trichurinae.

Trichuris muris (Schrank, 1788).

Specimens which are referred to this species occurred in the following hosts, usually in the intestine or caecum, but occasionally in the stomach:

Praomys tullbergi. (Locality, Adu.)
Mastomys erythroleucus. (Loc., Ibadan, Ife.)
Lemniscomys striatus. (Loc., Ibadan, Oyo.)
Cricetomys emini. (Loc., Adu.)
Cricetomys buchanani. (Loc., Kano.)
Taterona kempi. (Loc., Ibadan.)
Funisciurus anerythrus. (Loc., Adu, Okoya.)

Capillaria pearsei, sp. n. (Fig. 25).

Hosts: *Praomys tullbergi.*
Funisciurus auriculatus oliviae.

Position: intestine.

Locality: Adu.

Length, male (a single specimen only, from *Praomys*) 9·5 mm., female about 18 mm. Maximum thickness, male 0·06 mm., female 0·07–0·09 mm. Extent of bacillary bands uncertain. Length of oesophagus 3·5 mm. in male, 6 mm. in female. Cells of oesophagus transversely annulate, with a large nucleus at every sixth or seventh annulation (cf. *C. annulosa* Duj.).

Caudal end of male with a pair of postanal papillae. Spicule 1·45 mm. long and 0·0075 mm. thick. Spicule-sheath with regular transverse annulations internally.

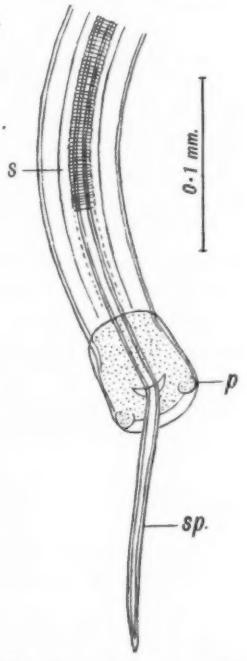

Fig. 25. *Capillaria pearsei.* Caudal end of male; ventral view. *p.* papilla; *s.* spicule-sheath; *sp.* spicule.

Tail of female bluntly rounded. Anus subterminal. Vulva 0·1–0·15 mm. behind posterior end of oesophagus, produced into a posteriorly-directed tubular cuticular outgrowth. Eggs with finely punctate shell, measuring (exclusive of the polar plugs) 0·04–0·05 mm. × 0·02–0·025 mm.

This species bears, in some respects, a close resemblance to *C. annulosa* (Dujardin, 1845) and to *C. schmidtii* (v. Linstow, 1874), both from rats. The spicule of the male is said to measure in the former 0·95 mm., in the latter 1·2–1·4 mm. in length.

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(*MS. received for publication* 31. v. 1928.—Ed.)

ON SOME NEW AVIAN CESTODES FROM THE SUDAN.

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(With Plates XVII and XVIII.)

1. **Taufikia edmondi**, gen. et sp. nov., from Rüppell's Vulture.

(Pl. XVII, figs. 1–3.)

Among Helminth material collected in the Sudan by the late Dr A. J. Chalmers, I have found some eight or nine mounted specimens of a Cestode, from the intestine of *Gyps rüppelli*, which has not, so far as I am aware, yet been described, and which apparently belongs to a new genus.

Anatomy. The total length of the worms varies between 27 mm. and 34 mm. In shape the strobila is very slender anteriorly (anterior half or third) but broadens rapidly posteriorly, as is the case in many other Anoplocephaline worms, and the whole is very extensile. The proglottids are very numerous (I have counted 158 in one worm, excluding 1–2 mm. of "neck," which measured 27·5 mm. in total length) and are all broader than long. The maximum breadth (posteriorly) of the strobila is about 2·5 mm. and the minimum is about 0·11 mm. The edges of the proglottids only become markedly salient when contracted. Mature proglottids (*i.e.* proglottids with formed genitalia, in which, however, the uterus has not commenced to develop) measure about 0·99 mm. in breadth and about 0·001 mm. in length, but these dimensions are of course subject to the degree of contraction. Fully ripe proglottids containing uteri full of eggs measure about 0·7 mm. in breadth and 0·09 mm. in length. One noteworthy feature about the proglottids is the rapid development of the uterus. In one worm the uterus first appeared as a distinct cavity in the region of the ovary in one proglottid and in the fifteenth proglottid behind this the uterus had extended laterally to its maximum breadth; in another worm this had occurred in the course of ten segments. This rapid development of the uterus corresponds of course to the rapid widening of the strobila behind a point in its length situated at about one-third or one-half of the total length from the scolex.

The scolex (measuring about 0·38 mm. long and 0·49 mm. broad) is generally globular in form (Fig. 1), with a rounded unarmed apex, and bears four large projecting suckers, circular in outline, each of which has a diameter of about half the breadth of the scolex. The narrow strobila immediately following the scolex shows variable signs of segmentation, so that an unsegmented neck may be regarded as absent.

The testes lie internally to the excretory canals and towards the dorsal side of the medulla, and are situated mostly or entirely in front of the transverse level of the ovary and uterus. They are not very numerous, rarely exceeding a dozen, and they measure, in *in toto* preparations, about 0·048 mm. in diameter.

The marginal genital ducts are irregularly alternating, the opening of the cirrus sac in the shallow atrium being anterior to that of the vagina, and both openings lying in the anterior half of the margin. Further, it is noteworthy that the two ducts pass *between* the single excretory vessel and longitudinal nerve of each side, thus being dorsal to the vessel and ventral to the nerve. The cirrus sac is small, measuring about 0·073 × 0·047 mm., but is well developed, containing a tight coil of vas deferens windings next the cirrus duct, the other end of the coil opening into a conspicuous vesicle (seminal vesicle) situated at the inner end of the sac, which in its turn communicates, through the wall of the sac, with the vas deferens proper. The wall of the sac is highly muscular. The cirrus tube is short, unarmed, and only capable of very slight protrusion into the atrium.

The vagina is a narrow tube leading straight from its aperture to the ovary and, in its course, devoid of any dilatation or covering of gland cells. The cirrus sac and vagina persist in gravid proglottids, the only change being the enlargement of the portion of vas deferens lying immediately outside the sac for sperm storage. The vagina, having arrived in the vicinity of the ovary, opens into an elongated channel, the ootype or fertilisation chamber, which latter receives the ducts from the ovaries and the vitelline gland, and gives rise to, at its lower extremity, the outpushings (covered proximally with shell gland cells) which represent the young uterus. The ovary consists of the usual two lobes and, with the compact globular yolk gland, is situated anteriorly in the proglottid (behind the row of testes) and very slightly towards the poral side.

As already mentioned, there are only two excretory canals, lying one on each side internal to the longitudinal nerves. These canals are broad and, in contracted segments, convoluted, and they are regularly united between every two segments by still broader transverse canals which stretch across the strobila and project on each side under and external to the lateral nerves for a short distance after uniting with the longitudinal canals (Fig. 2). The two longitudinal nerves are large, each being nearly half the breadth of the longitudinal excretory canals.

The musculature is well developed. The medulla is delimited by a thin layer of transverse fibres and immediately external to this is a regular layer of large bundles of fibres (10–40 fibres in the bundle) constituting the chief layer of longitudinal muscles. Outside this layer again (*i.e.* in the space between this layer and the subcuticula) are scattered smaller bundles of fibres (6–12 in the bundles), which may be regarded as a second layer. In addition to this parenchymal musculature there is a distinct though thin layer of

subcuticular muscle fibres, one layer deep, underlying the cuticle. The medulla and cortex (the former twice the thickness of the latter) are also traversed by numerous distinct dorso-ventral muscle fibres.

In the gravid proglottid the uterus has extended from a central area throughout the entire medulla in the form of prolonged and occasionally branched conspicuous lobes containing numerous eggs. The eggs measure externally about 55 microns in diameter, the outer shells being quite thin. The contained oncospheres are a little smaller, measuring about 47·5 microns in diameter. The individual hooks of the embryo measure about 25·6 microns in length.

Systematic Position. This Cestode is evidently an Anoplocephalid, but if we employ the key to the genera provided by Baer (1927, p. 217), it is evident that the worm cannot be referred to any existing genus. On the other hand, it is evidently most closely related to the genera *Prototaenia* Baer, *Bertiella* Stiles and Hassall and *Aporina* Fuhrmann (*vide* Baer's Monograph for definitions of these genera). It differs, however, from Baer's new genus *Prototaenia* in that the suckers are not pedunculated, the genital ducts pass ventrally to the nerve, it possesses an unarmed cirrus, the eggs are without a pyriform apparatus and it is parasitic in a bird. It differs from *Bertiella* in that the sexual ducts pass ventrally to the nerve, it has a well-developed though small cirrus pouch, it lacks a layer of gland cells surrounding the vagina, the uterus extends laterally external to the excretory canals, the eggs lack a pyriform apparatus and it is parasitic in a bird. And it differs from *Aporina* in that the sexual ducts persist in gravid segments and pass ventrally to the nerve, it has a well-developed though small cirrus pouch and the testes are situated anteriorly to the ovary complex. I am therefore compelled to create a new genus for this Cestode from Rüppel's Vulture and I propose the name *Taufikia* (suggested by Dr Wenyon, after a station in the Sudan). The new genus is to be defined as follows:

Taufikia. Anoplocephalinae of medium size. Genital pores irregularly alternate. Genital ducts pass dorsally to the excretory canals and ventrally to the longitudinal nerves. The testes form a continuous field internal to the excretory canals and anterior to the ovary complex. Cirrus sac small but well developed and situated anterior to the vagina, with an unarmed cirrus. Ovary complex single and more or less poral in position. Vagina devoid of gland cells and, with the cirrus pouch, persistent in gravid segments. Uterus with lateral diverticula extended beyond and ventrally to the excretory canals. Eggs devoid of a pyriform apparatus. Parasitic in Birds.

The type-species described above is *T. edmondi* and is diagnosed as follows:

Strobila about 27–36 mm. long, with a maximum breadth of about 2·5 mm.; slender anteriorly, broad posteriorly. Numerous proglottids. Scolex globular (about 0·38 × 0·49 mm.) with large suckers (*c.* 0·024 mm. diameter). Unsegmented neck absent. Testes about twelve in number. Genital ducts open anteriorly on margin. Cirrus sac small (*c.* 0·073 × 0·047 mm.). Ovary complex

slightly poral in position. Two large longitudinal excretory canals only, united intersegmentally by transverse canals. Host and locality: *Gyps rüppelli*, Sudan.

2. **Lateriporus merops,** sp. nov. from *Merops apiaster* Linn.

(Pl. XVII, figs. 4–8.)

Up to the present time eight species of *Lateriporus* have been described: *L. teres* (Krabbe, 1869) from Anseriformes of Europe, Asia and the United States, *L. cylindrica* (Clerc, 1903) from *Larus canus* (Lariformes) of the Ural Mountains, *L. propeteres* Fuhrmann, 1908, from *Nettium brasiliense* (Anseriformes) of South America, *L. biuterinus* Fuhrmann, 1908, from various Anseriformes of South and Central America, *L. spinosus* Fuhrmann, 1908, from *Canchroma cochlearis* (Ciconiiformes) of South America, *L. geographicus* Cooper, 1921, from *Somateria v-nigra* (Anseriformes) of Canada, *L. mahdiaensis* Joyeux, 1923, from *Ardea purpura purpura* (Ciconiiformes) of North Africa, and *L. fuhrmanni* Southwell, 1925, from a "large grey eagle" of Northern Nigeria. The present new species, *L. merops*, from the intestine of *Merops apiaster*, the common European Bee-Eater which migrates through the Sudan, is therefore from a new bird group (Coraciiformes) and a new geographical area.

I possess but one specimen (mounted in balsam) which is fragmented, portions of the strobila having been sectionised. The remaining fragments are about 44 mm. in total length and the whole worm may have measured about 60–70 mm. in length. The maximum breadth (gravid segments) is 0·81 mm. The number of proglottids is very large and the posterior margins are imbricated. One noteworthy feature about the strobila is that it is, save in the gravid region, nearly cylindrical in form, transverse sections approaching the circular (Fig. 7). The individual proglottids posteriorly are almost square in outline.

The scolex is of the usual *Lateriporus* type (Fig. 4) and measures about 1·49 mm. in length and 1·16 mm. in breadth (at level of suckers). The rostellum encloses anteriorly a globular "bouchon musculaire" which bears the single circle of about 22 hooks. The hooks measure about 40 microns in length and are of the form shown in Fig. 5. The suckers are large, measuring about 0·208 mm. lengthwise (*i.e.* parallel with the long axis of the scolex) and are apparently unarmed. A short unsegmented neck succeeds the scolex.

Mature proglottids, *i.e.* proglottids with formed genitalia but with the uterus undeveloped or only slightly developed, measure in *in toto* preparations about 0·33 mm. long and 0·5 mm. broad. The general arrangement of the genitalia (which appears to be distinctive of the present species) is shown in Fig. 6. The yolk gland is very large (*c.* 100 microns in diameter) and touches the posterior border of the proglottid in the middle line, and the ovary also is large, the two lobes occupying the centre of the segment and one of them almost reaching the anterior border. The unilateral genital apertures are

situated a short distance in front of the middle point of the margin, both opening into a small atrium. The cirrus sac, anterior to the vagina, is of fair size (*c.* 150 microns long and 40 microns wide) and extends internally just beyond the ventral excretory canal. The vas deferens forms a conspicuous coil immediately on leaving the sac. I cannot ascertain from my preparations any details of the sac structure. So far as I can see, the testes are about 12–14 in number and measure in *in toto* preparations about 30 microns in diameter. They are situated centrally in the posterior half of the segment, surrounding the ovary and vitelline gland.

The vagina is a fairly broad tube (about one-third the breadth of the sac) which runs directly between the lobes of the ovary where it ends in a small dilatation—the receptaculum seminis. The uterus arises between the ovary lobes and ultimately (in gravid segments, Fig. 8) occupies the whole of the medulla between the excretory canals. My preparations are not sufficiently good or numerous to allow me to describe further details of the genitalia. The intra-uterine eggs have, in my material, not sufficiently developed to form hooks and measure about 22 microns in diameter.

Two pairs of excretory canals are present, as described by Fuhrmann (1908) in *L. teres*, and, as in this species, the genital ducts pass dorsally to both canals. It is also noteworthy that, as in *Dendrouterina* and some other genera, on one side of the strobila the small "dorsal" canal is dorsally placed relatively to the larger "ventral" canal, and, on the other side, ventrally placed. The two large ventral canals are united transversely by a transverse canal at the posterior end of each proglottid and attain a great width in gravid segments.

The medulla is not delimited from the cortical parenchyma by a layer of transverse muscle fibres (so differing from the condition in *L. teres*) but only by a thin layer of small bundles of longitudinal muscle fibres, outside which lie smaller bundles and isolated fibres. These bundles are only visible in fully mature segments and are not fully developed in the immature condition (Fig. 7). A layer of very minute longitudinal muscle fibres also underlies the cuticle.

3. **Unciunia sudanea,** sp. nov. from *Numida ptilorhyncha.*

(Pl. XVIII, figs. 9–11.)

Up to the present time only one species of the genus *Unciunia* Skrjabin, 1914 has, so far as I know, been described, viz. *U. trichocirrosa*, from a Falcon in Paraguay: hence the present tapeworm from the intestine of a well-known species of Guinea-Fowl found at Tonga in the Sudan represents a second species from a widely different zoo-geographical region and from a different family of Birds. *Unciunia sudanea*, the new species, has a strobila nearly 40 mm. in length when full grown with terminal gravid segments and is therefore probably about the same length as full-grown specimens of *U. trichocirrosa*. The maximum breadth of the strobila is to be found usually some distance in

front of the terminal elongated segments and measures about 0·94 mm. The number of segments is considerable (113 in one worm 34 mm. long). Immature proglottids are either broader than long or quadrate and are imbricated at their extremities: mature proglottids are nearly always quadrate in form and are also imbricated; gravid proglottids are always longer than broad (*c.* 1·56 mm. long as a maximum and 0·66 mm. broad). The scolex (Fig. 9) is globular in form with no marked apical projection beyond the suckers (so differing from *U. trichocirrosa*) and the only trace of a muscular rostellum is a slight thickening underlying the apical cuticle. The scolex roughly measures 0·46 mm. broad and 0·49 mm. long. The suckers are oval in form and measure about 0·29 × 0·18 mm. A very short unsegmented neck region is present in some extended specimens but it is usually invisible.

In a mature proglottid (Fig. 11) the testes are similar in number, size and disposition to those of *U. trichocirrosa*, *i.e.* there are about 30–35 of them and they lie at the sides of and posterior to the ovary complex, posterior to the vagina on one side and to the cirrus sac on the other and between the excretory canals. On the other hand, the cirrus sac is very large (*c.* 0·34–0·41 mm. long and 0·36 mm. wide; it is only 0·11 mm. long and 0·074 mm. broad in *U. trichocirrosa*), extending from its pore opening into the deep atrial pit on one side nearly to (in some cases beyond) the excretory canal of the opposite side. Its wall is muscular but the contained vas deferens is either straight or merely curvilinear (no coils) and continuous with the cirrus duct. I have not observed a protruded cirrus and I have also not been able to detect, either in sections or *in toto* preparations, any "hairs" or chitinous spine at the outer extremity of the cirrus sac, such as Skrjabin described in *U. trichocirrosa*. On emerging from the long sac the vas deferens becomes very much coiled (forming a mass lying dorsal to the anterior end of the ovary) before extending to the testes. The external opening of the genital atrium lies either at or just behind the middle point of the margin length.

The vagina is a simple tube opening into the genital atrium just behind the cirrus sac. It extends inwards and dorsally and slightly anteriorly (running parallel at first with the cirrus sac) to the level of the outer testes and then, becoming somewhat dilated, bends backwards and ventrally and, at the level of the internally situated testes, opens into the large dorsally placed ovoid receptaculum seminis. The whole of the vagina wall, up to the receptaculum, is covered with a layer of conspicuous gland cells, which attain their maximum size in the dilated region. From the inner end of the receptaculum emerges a dorsally placed tube which, after extending a short distance posteriorly, bends on itself (the ootype, which receives the opening of the vitelline gland cells) and runs forward ventrally to connect with the lobes of the ventrally placed ovary. The ovary at first consists of a median strand of tissue extending forwards to the level of the cirrus sac but it subsequently broadens anteriorly and becomes much lobulated, narrowing posteriorly to a single lobe in contact with the ventral wall of the receptaculum. The general arrange-

ment of the genital organs, with their ducts and pores, is thus substantially the same as in *U. trichocirrosa*, though Skrjabin was unable to describe the arrangement found in the mature proglottids of that species.

There exist the usual two pairs of excretory canals—dorsal and ventral—the irregularly alternating genital ducts passing between the two canals of each side and ventral to the longitudinal nerves.

The medullary region is delimited from the cortical by several layers of transverse muscle fibres, immediately outside which is a somewhat irregular layer of small bundles of longitudinal muscle fibres and outside these still smaller longitudinal fibres extending nearly to the inner edge of the subcuticula.

Of gravid proglottids I possess only transverse sections and in these it is seen that the whole of the medullary area is occupied by fairly thick-walled capsules in close mutual contact, each containing a single egg. I am uncertain as to whether these capsules are formed inside an expanded uterus or have developed independently in the parenchyma, but I am inclined to the latter view. The polygonal capsules are roughly 40 microns in diameter and the contained eggs about 30 microns. The egg shells are thin and apparently two in number. Hooks are not developed at this stage.

I may mention that in the host from which this new species of *Unciunia* was obtained specimens of a species of *Raillietina* (= *Ransomia* Fuhrmann. Davaineidae) were also present, and were superficially similar to *U. sudanea*.

4. A Cestode with an armed scolex from *Numida ptilorhyncha*.

(Pl. XVIII, figs. 12–16.)

Anatomy. This Cestode, which, on account of its peculiar combination of characters and lack of gravid segments in my material, I am unable to relegate to its appropriate genus, consisted of two scolices (one of which I dissected in order to see the hooks on the rostellum) and six portions of strobila. I am unable therefore to give the total length of either worm, though I should be disposed to assume a length of at least 50 mm. and probably more in the case of worms with gravid segments. The maximum breadth of my portions of strobila (in the immature region) is 3·7 mm., while the strobila in the mature region only measures 1·5 mm. The scolex (Fig. 12) is not marked off from the strobila by any constriction or narrowing, being of the same diameter (0·81 mm.), and is only 0·38 mm. long (from the apex to the first annulus). The four suckers are small globular structures (0·166 mm. in diameter) very deeply placed in the substance of the scolex at the sides of the muscular rostellum, and opening, *via* deep tubular pits, on the extreme anterior surface of the scolex. The suckers are thus of an unusual type. The rostellum is a broad muscular dome-shaped evaginable structure, 0·23 mm. broad, which carries a circle of a very large number (about 80, so far as I can estimate) of closely set hooks of the form shown in Fig. 13. The hooks are apparently all about

the same size and measure approximately 60 microns in length. As already implied, there is no unsegmented neck.

The immature proglottids of this species are extremely short in proportion to their breadth. Thus in two regions of the immature strobila the proglottids measure in breadth 3·7 mm. and 2·9 mm. and in length measure respectively only 0·17 mm. and 0·11 mm. The mature proglottids, on the other hand, are considerably longer relative to their breadth, though still very short; a typical mature proglottid measures 2·36 mm. in breadth and 0·38 mm. in length. As already stated, gravid proglottids are absent in my material.

The arrangement of the organs in a mature proglottid (Fig. 15) is as follows. The marginal genital pores in all cases open into a deep narrow atrium situated near the extreme anterior end of the proglottid. The pores are practically unilateral, but very exceptionally the pores open on the opposite margin: thus, in one of my fragments of strobila 4 mm. in length and containing 22 segments, the pores open on one side in 17 segments but on the opposite side in the other 5 segments; on the other hand, in another fragment 5 mm. in length containing 32 segments, all the pores open on one side (the left).

The cirrus sac, with its opening, lies anterior to the vagina, is very narrow for the first two-thirds of its length but swells into a bulb at its inner extremity, and measures 0·19 mm. in length. The contained cirrus tube is perfectly straight, *i.e.* shows no coils, and is quite unarmed. The vas deferens, on emerging from the sac, is a fairly broad duct which runs dorsally to the large ventral excretory canal and the lateral nerve, penetrates the dorsal portion of the large porally placed multilobed ovary and connects with the testes, which are distributed along the breadth of the proglottid between the ovary on the poral side and the excretory canal aporally. The testes (about 44 microns in diameter) are very numerous (over 100 in number I should say) and closely packed, and they occupy the whole of the medulla situated between the two longitudinal canals and the transverse canal, save for a small strip anteriorly and the space occupied by the ovary complex.

The vagina is a fairly broad duct which runs parallel with and on the same horizontal level as the sac and the vas deferens, and traverses the centre of the lobed ovary: it shows no marked dilatation and of course receives the duct from the spherical vitelline gland, which is situated on the internal side of the ovary. I am unable, in my material, to ascertain the exact position or extent of the shell gland and the finer ducts, nor can I detect any sign of a uterus. The ovary complex is therefore situated on the extreme poral side of the proglottid.

There is only one pair of excretory canals, viz. the large ventral, and these are united across the middle line by a transverse canal of about the same diameter which lies along the hind border of each proglottid. The lateral longitudinal nerves are very large and lie just external to the excretory canals.

The medulla is about half the breadth of the cortex and is delimited by three or four layers of thin transverse muscle fibres. Outside these is a very

pronounced zone of longitudinal muscle bundles, altogether occupying more than half the breadth of the cortex. The innermost bundles are large, consisting of from 50 to 80 fibres, while the outermost are small, containing but two or three fibres, the intermediary bundles being intermediate in size. A single layer of circular muscle fibres underlies the cuticle and under this is a single layer of longitudinal fibres.

Systematic Position. To which family of Cyclophyllidean Cestodes does this worm belong? If we consider the definitions of the eight recognised families, it is evident that, if we adopt these, the worm must belong to one or other of the two large families, the Hymenolepididae and Anoplocephalidae, the sole definitions of which appear to consist almost entirely of a lack of those characters which more or less sharply define the remaining six. The family of the Davaineidae appears to be solely based on the presence of numerous hammer-shaped hooks on the rostellum of the scolex—the implication being that a tapeworm possessing a scolex devoid of these hooks cannot be a Davaineid (!). Similarly, a worm like that under consideration possessing an armed scolex cannot *ipso facto* be an Anoplocephalid, even though all the segments are much broader than long and all its other characteristics are not incompatible with the "definition" of this family. The only course therefore, if we adopt the prevalent system of classification, is to refer the present tapeworm to the Hymenolepididae, even though the testes (possibly owing to the short segments) do not extend posteriorly to the female organs. But further than this we cannot go, since we are ignorant of the anatomy of the gravid proglottids, and, as regards its other characters, they do not appear to coincide with the definition of any known genus in the family. The only alternative is to adopt an unorthodox attitude and assume that the present worm is an Anoplocephalid which has developed an armed rostellum and in this case it might very well prove, when we have ascertained the form of its uterus, to be a new species of one of the genera which its known characters at present appear more or less to fit, *e.g. Andrya*, *Inermicapsifer* (with its four suckers lying at the bottom of muscular pouches) or perhaps *Multicapsiferina* (and *M. linstowi* is known to infest the same host as the present worm, viz. *Numida ptilorhyncha*). Evidently the safest course at present is to leave the worm unplaced and unnamed, so that someone with a larger experience of Cyclophyllidean Cestodes than I possess will be able to determine its correct systematic position when the description of its anatomy is complete.

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EXPLANATION OF PLATES.

All figures drawn under the camera lucida.

PLATE XVII.

Figs. 1–3. *Taufikia edmondi*, gen. et sp. nov.

Fig. 1 (× 39): the scolex. Fig. 2 (× 56): a mature proglottid from the dorsal aspect. Fig. 3 (× 56): portion of a thick transverse section of a mature proglottid, with the uterus slightly developed.

Figs. 4–8. *Lateriporus merops*, sp. nov.

Fig. 4 (× 87·5): outline of scolex. Fig. 5 (× 395): hook from rostellum. Fig. 6 (× 87·5): a mature proglottid from the dorsal aspect. Fig. 7 (× 180): transverse section across an immature proglottid. Fig. 8 (× 39): a gravid proglottid with the uterus full of eggs.

PLATE XVIII.

Figs. 9–11. *Unciunia sudanea*, sp. nov.

Fig. 9 (× 56): outline of scolex. Fig. 10 (× 56): transverse section of a mature proglottid. Fig. 11 (× 56): dorsal view of a mature proglottid.

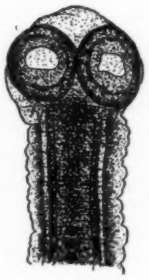
Figs. 12–16. A Cestode from *Numida ptilorhyncha*.

Fig. 12 (× 39): outline of the scolex. Fig. 13 (× 260): a hook from the rostellum. Fig. 14 (× 17·5): outlines of immature segments. Fig. 15 (× 27·5): mature proglottid from the ventral aspect. Fig. 16 (× 27·5): transverse section across a mature proglottid.

REFERENCE LETTERS OF FIGURES.

AT, genital atrium (cloaca); *CS*, cirrus sac; *DC*, dorsal excretory canal; *HK*, hooklets on rostellum; *ILM*, internal layer of longitudinal muscles; *LM*, longitudinal muscles; *LV*, lateral excretory canal; *N*, lateral longitudinal nerve; *OLM*, outer layer of longitudinal muscles; *OV*, ovary; *OVD*, oviduct; *RS*, receptaculum seminis; *SO*, opening of sucker on anterior surface of scolex; *T*, testes; *TRM*, transverse muscle fibres; *TRV*, transverse excretory canal; *UT*, uterus; *VAG*, vagina; *VC*, ventral excretory canal; *VD*, vas deferens; *VIT*, vitelline gland.

(*MS. received for publication* 21. VI. 1928.—Ed.)



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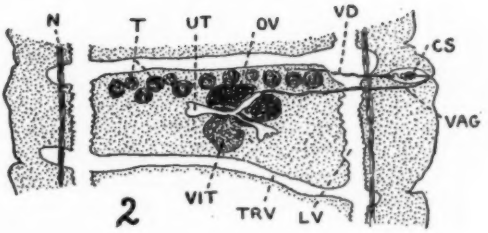
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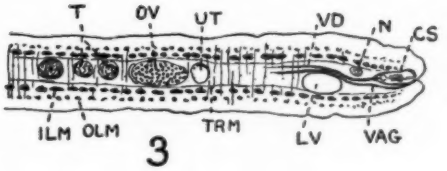
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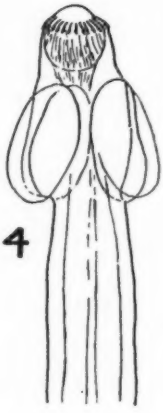

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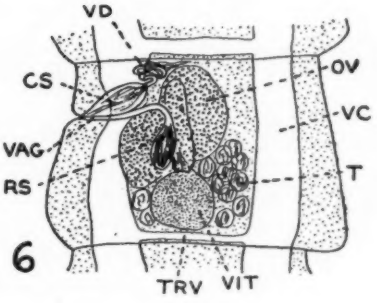
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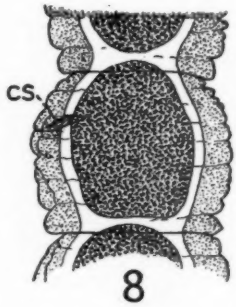
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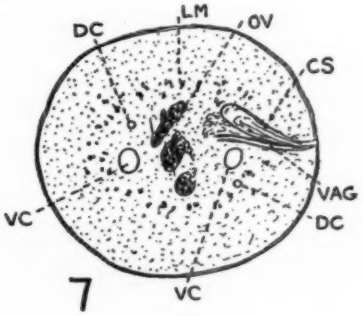
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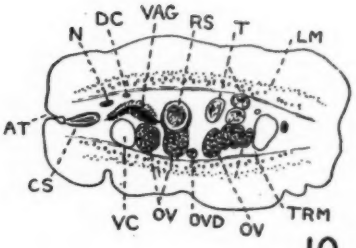

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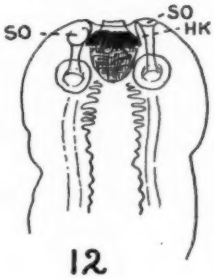

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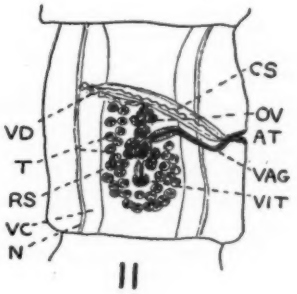

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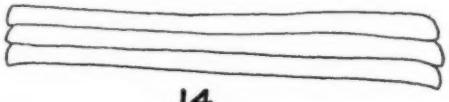

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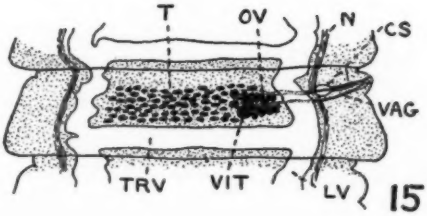

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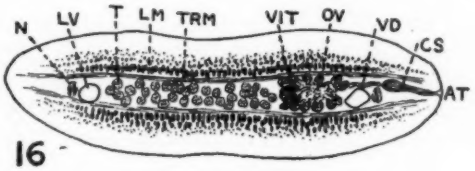

16

UNIV. OF MICH.

REPORT ON A COLLECTION OF CESTODA, MAINLY FROM EGYPT.

PART III. CYCLOPHYLLIDEA (CONCLUSION): TETRAPHYLLIDEA.

By F. J. MEGGITT.

University of Rangoon.

(With Plate XIX.)

Family ACOLEIDAE Ransom, 1909.

Acoleus Fuhrmann, 1899.

796. ? **A. vaginatus** (Rudolphi, 1819).

Host. *Hoplopterus spinosus.*

A few specimens very badly preserved and pigmented: coating them was a deposit which entirely obscured the internal anatomy and could not be removed. The internal anatomy therefore could not be elucidated. Length 10*, greatest breadth 0·47. Scolex 0·54 dia. As the only species without a rostellum recorded from this host is *A. vaginatus* the specimens are listed under that name.

Progynotaenia Fuhrmann, 1909.

708 *b*, 781 *b*. **P. evaginata** Fuhrmann, 1909.

Host. *Oedicnemus crepitans* (708 *b*): *Spatula clypeata* (781 *b*).

The material agreed with Fuhrmann's description (1909, p. 49). Rostellar hooks 20. Rostellum enters first proglottis. Genital ducts pass ventrally to excretory vessels. Testes 16–22, in two groups lateral to female glands. Cirrus sac 0·42–0·5 × 0·09–0·13: cirrus armed. Uterus a septate sac.

723 *a*. **P. flaccida** n.sp. (Pl. XIX, fig. 7).

Host. *Recurvirostra avocetta.*

Length 1·2–1·4, greatest breadth 0·52–0·66. Scolex 0·23 dia. Rostellum 0·04 dia. Rostellar hooks 20, in two rows, long and short hooks alternating: long hooks 0·031–0·034, short hooks 0·007–0·008. Segments few, maximum 8–9. Musculature feeble, consisting of two layers, each of alternating transverse and longitudinal muscles, the outermost layer being of transverse muscle. Longitudinal muscle bundles of not more than four fibres, usually of a single fibre. In young segments inner longitudinal layer very indistinct: in gravid ones the arrangement of both confused, often appearing like three layers.

* The measurements throughout this paper are given in mm.

Genital pore irregularly alternating, in anterior portion of proglottis margin. Genital cloaca large, extending one-sixth across proglottis. Cirrus sac large, directed anteriorly, extending past centre of proglottis, with its inner end curved dorsally, reaching and pressing outwards the longitudinal muscles: dorso-ventrally it nearly fills the segment. Cirrus armed with numerous fine spines. Testes 32, 18 aporal and 14 poral. Receptaculum seminis very large and spherical. The double circle of hooks with their large size, together with the number of testes, distinguish this species from others of the same genus.

804, 812. **P. foetida** n.sp. (Pl. XIX, fig. 8).

Host. *Oedicnemus crepitans.*

Length 4, greatest breadth 0·4. Scolex 0·25–0·3 dia. Rostellum 0·11 dia. Rostellar hooks 20, 0·046–0·051 long. Testes 5–6 poral, 9–10 aporal, posterior and lateral to uterus. Cirrus sac in five consecutive segments: 0·98 × 0·147; 0·9 × 0·208; 0·54 × 0·17; 0·41 × 0·13; 0·29 × 0·09; in young segments extending transversely across proglottis, in old segments directed obliquely anteriorly, reaching centre of anterior margin of proglottis and nearly reaching aporal excretory vessel. Genital atrium evertable as a spherical knob. The most closely allied species is *P. pauciannulata* Baczynska, 1914, from which the present specimens differ in the size and shape of the hooks, the greater number of the testes, and the larger size of the cirrus sac.

695 *a*. **P. odhneri** Nybelin, 1914 (Pl. XIX, figs. 4 and 9).

Host. *Hoplopterus spinosus.*

The material agreed in all respects, except size and shape of rostellar hooks, with Nybelin's description (1914, p. 225). Hooks 0·052–0·056 instead of 0·059, and were not so thick at the guard: the length to the guard divided by the total length was 0·74–0·834 instead of 0·686. Ovary at first bilobed, each lobe being subdivided into three, later compact.

The tube contained a label referring to the collection of Prof. Fuhrmann, to whom the author is indebted for the name of the species to which it refers. According to this label the species is a co-type of *P. pauciannulata* Baczynska, 1914. The latter form has however rostellar hooks 0·044 long: the specimens therefore cannot belong to that species. It is probable that here, as in other cases, there has been a confusion of labels.

Family BIUTERINIDAE Meggitt, 1927.

Sub-family Biuterininae Meggitt, 1927.

Biuterina Fuhrmann, 1902.

711. **B. fallax** n.sp. (Pl. XIX, fig. 10).

Host. *Merops apiaster.*
Locality. Marg.

Length 20, greatest breadth 0·4–0·5. Rostellar hooks 18–20, of the typical

Biuterina shape, in two rows, 0·044–0·048 long. Testes 12. Cirrus sac 0·09 × 0·026, narrow, extending just past excretory vessels. Uterus distinctly bilobed, the division extending nearly to paruterine organ. Latter long and narrow, extending to anterior border of proglottis, later breaking down into a septate sac occupying the whole of the segment. The most gravid proglottides appear as though containing a partly septate uterus with rather thicker walls than usual. The number and size of hooks separate this form from all others of the same genus except *B. rectangula* Fuhrmann, 1908, and *B. mertoni* Fuhrmann, 1911. From the former it differs in the number of testes, complete division of the uterus, and absence of a muscular genital cloaca: from the latter—a complete description of which is not accessible here—in the number of testes.

752. **B. meropina macrancristrota** Fuhrmann, 1909.

Host. *Merops apiaster*.

672, 673, 704, 777. **B. rectangula** Fuhrmann, 1908.

Host. *Coracias galbula* (673, 777): *Falco tim* (704).

The material from tube 672 contained three scoleces, all devoid of hooks. This was also the case with Fuhrmann's specimens (1909 *b*, p. 417), so that in all probability the rostellum of this species is unarmed. Radial musculature surrounding genital pore internally capable of being everted in the form of a sphere pierced by the cirrus. Testes 10–15. Cirrus sac 0·15 × 0·08, containing a large vesicula seminalis. In other respects the material agreed with Fuhrmann's description.

696 *a*. **B.** sp.

Host. *Coracias galbula*.

A single specimen. Length 6, greatest breadth 0·25. Scolex 0·43 dia. Rostellum 0·14 dia. Rostellar hooks approximately 30, 0·02 long: lack of material prevented manipulation to show shape. Genital pore mostly on one side, at anterior third of proglottis margin. Cirrus sac extending half-way across proglottis. Testes 8–12. All proglottides immature. The relative size of the cirrus sac distinguishes the present form from all others of the same genus, but the small quantity of material and its immaturity precludes the possibility of creating a new species: the form is therefore left unnamed.

Family MESOCESTOIDIDAE Fuhrmann, 1907.

Mesocestoides Vaillant, 1863.

731. **M. elongatus** n.sp. (Pl. XIX, fig. 3).

Host. Wolf.

Length 15–25, greatest breadth 0·44. Scolex 0·3–0·32 dia., with prominent suckers. Genital pore in centre of proglottis or slightly anterior: genital cloaca small, forked, with the apex directed posteriorly. Testes approximately

60, in two groups, separated along the centre line by the cirrus sac and female glands, otherwise filling segment, in two layers dorso-ventrally. Cirrus sac 0·15–0·16 × 0·056, usually reaching anterior border of segment: cirrus unarmed. Ovary sac-like. Uterus, where seen, a narrow tube extending to anterior margin of proglottis. Vitelline glands double, on posterior end of ovary: as mentioned by Cameron (1925, p. 34), the definition of the Cyclophyllidea previously given (Meggitt, 1924, p. 11) requires the addition of "double in Mesocestoididae" together with a corresponding alteration in the definition of the family.

Family NEMATOTAENIIDAE Lühe, 1910.

Nematotaenia Lühe, 1899.

746, 749, 766, 769. **N. dispar** (Goeze, 1782).

Host. *Bufo sartica* (746): *Rana madagascariensis* (749): (? *Cato.*) *atr.* (766).

Family TAENIIDAE Ludwig, 1886.

Catenotaenia Janicki, 1904.

726. **C. pusilla** (Goeze, 1782).

Host. *Mus albellus.*

The specimens agreed in all respects with the description of Janicki (1906, p. 575) except that the genital pore was in the centre of the proglottis margin instead of slightly anterior and the testes were more than 100 instead of 70.

Cladotaenia Cohn, 1901.

748. **C. cylindracea** (Bloch, 1782).

Host. *Circus rufus.*

770. **C. secunda** n.sp. (Pl. XIX, fig. 2).

Host. Unknown.

Length 30, greatest breadth 1·2. Scolex absent. Cirrus sac 0·15–0·16 × 0·038–0·04, extending to longitudinal excretory vessels. Testes 75–100, lateral and anterior to female glands, more numerous aporally. Genital pore irregularly alternating, at centre of proglottis margin. Ovary median, posterior, crescent-shaped, with convexity directed anteriorly and produced into numerous processes. Vitelline gland compact, posterior to centre of ovary. Uterus a median stem with approximately 15 lateral branches each side: in the present material anterior third of proglottis occupied by an unbranched portion of uterus. Eggs 0·017–0·02 dia., without radially striated coat. The present form most resembles *Taenia lateralis* Fuhrmann (1909, p. 54), from *Haliaëtus vocifer*, White Nile. It differs in the central position of the ovary, the relative size of the cirrus sac, and the more extended arrangement of the testes.

Taenia Linnaeus, 1758.

799 *b*. **T. hydatigena** (Pallas, 1766).

Host. Label indistinct.

Two proglottides only. Uterus with, each side, 5–10 lateral branches which only subdivide slightly.

73, 78, 79, 82 *a*. **T. pisiformis** (Bloch, 1782).

Host. Dog (78, 79): jackal (82 *a*).

Locality. Cambridge (78, 79).

653 *c*, 656, 661 *a*, 662, 663, 782. **T. taeniaeformis** (Batsch, 1782).

Host. *Mus rattus* (653, 661 *a*, 662) liver: *Rattus rattus alexandrinus* (663) liver: *Felis domestica* (656).

The material agreed with Hall's description except in the following points. Small rostellar hooks 0·208–0·242 long: total number of hooks 60. Cirrus sac extending to, not past, longitudinal excretory vessels. Testes nearer excretory vessels. A much smaller space free from genitalia along posterior margin of proglottis. Uterine diverticulae 9–11 each side. Tube 782 contained a few fragments, devoid of scoleces and genital organs, with a label "Cyst. fasciol.": preservation bad, the material having been dried and remoistened.

728. **T. triserrata** n.sp.

Host. *Felis* sp.

Locality. Paraguay.

Length 25, greatest breadth 1·2. Scolex 1·0 dia. Rostellum 0·6 dia. Rostellar hooks in three rows: the more anterior 0·2 long, the middle 0·16 long, and the more posterior 0·12 long: the hooks of the three rows alternating with one another. Shape of hooks similar to that of *T. monostephanos* v. Linstow, 1905 (Hall, 1919, p. 38) from a Russian lynx; the peculiar shape may be due to fragmentation of exceedingly brittle hooks. Preservation of material very poor: details of internal anatomy could not be ascertained from whole mounts, while sectionising caused the specimens to crumble. End proglottides with eggs of the typical *Taenia* structure, 0·032 × 0·027, apparently in a sac-like uterus or one in which the branches had coalesced.

"If von Linstow's material is to be regarded as actually representative of the species to which it belongs, then it should be given generic or subgeneric rank on the basis of the single crown of hooks, which is, if anything, more striking than the entire absence of hooks in *Taeniarhynchus saginatus*.... It has not seemed advisable to create a new genus for this species for the reason that new data should be added in confirmation of the idea that the conditions reported were normal" (Hall, 1919, p. 39). The same argument applies to the present species. The small number of strobilae (two) and the bad preservation of the material are factors too important to ignore. It should be noted that

both the abnormal species of *Taenia* are from species of *Felis* and both have hooks of the same shape.

309. **T.** sp.

Host. Dog.

Locality. Haifa, Palestine.

A few fragments of a strobilus in a bad state of preservation and altogether unidentifiable.

Taeniarhynchus Weinland, 1858.

668, 832. **T. saginatus** (Goeze, 1782).

Host. Man.

Locality. Mingalodone (Rangoon).

Family TETRABOTHRIIDAE Fuhrmann, 1907.

The systematic position of this family is still under discussion. Placed by Fuhrmann (1907, p. 289) in the Cyclophyllidea, it was removed by Nybelin (1922, p. 205) to the neighbourhood of the Abothriinae (Pseudophyllidea): Poche (1925), following Nybelin, placed it as a tribe of the Bothriocephaloidea Diesing, 1850. Recently Baylis (1926, p. 172) has emphasised its affinities with *Dinobothrium*, previously regarded as a Tetraphyllidean, and suggested that this genus may also be included within the family.

The first to question the Cyclophyllidean affinities of the family was Nybelin, who held

(1) the anterior vitelline gland to be derived from the follicular sheath of the Abothriinae by a process of condensation, transitional forms being *Priapocephalus* and *Parabothrium*;

(2) the four suckers to be derived from the two bothridia of the latter sub-family by longitudinal division, the auricular appendages corresponding to a terminal plate;

(3) the rudimentary uterine pore as the last stage in a process of degeneration from the fully developed one of the Abothriinae.

The argument at first appears reasonable, though further consideration raises doubts. The division between the Cyclophyllidea and the Pseudophyllidea, or between any of the main divisions of the Cestoda, rests mainly on the life-history, the structure of the scolex and that of the vitelline gland: the last two characters are dismissed by Nybelin by assumptions only. Before repudiating the present classification it should be shown clearly that the basis upon which it rests is untenable, either by reason of the variability of the characters employed, or by virtue of their insignificance as compared with others.

With regard to the first point, *Abothrium* has two weak bothridia: *Tetrabothrius* four true suckers: *Abothrium* a terminal plate, *Tetrabothrius* auricular appendages (according to Szpotanska, 1925, true appendages not separated

from the suckers in any way, but according to Fuhrmann, 1904, p. 745, separated from them by a membrane though sucker-like in character); no transitional forms occur, though in *Priapocephalus* there is an aberrant form of scolex bearing no resemblance to either of the other two but being more similar to those of the Lecanicephalidae. There is no record, beyond the dubious case of *Pyramicocephalus*, of four suckers in the Pseudophyllidea. *Abothrium* has a sheath of vitelline follicles, *Tetrabothrius* a compact vitelline gland anterior to the ovary. Beyond the fact that in certain species of the latter genus the gland is rather diffuse, transitional forms are absent. The tendency in the Amphicotylidae is rather towards a marginal and lateral position of the follicles than towards a condensation (Nybelin, 1922, p. 176, Fig. 90; p. 181, Fig. 93; p. 188, Fig. 99). Again, a compact gland is not found outside the Cyclophyllidae with the dubious exception of certain species of *Tylocephalum* mentioned by Southwell (1925, pp. 267, 287).

In these two main characters the forms are distinct. The life-history of no member of the Tetrabothriidae is known, so, with regard to that character, no comparison can be made. With the exception of the presence of a uterine pore, no characters are adduced by Nybelin to replace those dismissed. The presence of this pore in other families is held to be of no more than generic importance, *e.g.* the Acoleidae contains forms with (*Gyrocoelia*) and those without uterine pores, similarly the Ichthyotaeniidae has forms with (La Rue, 1914, p. 12) and without (*Gangesia*—Woodland, 1924 *c*, pp. 445, 446) uterine pores. With a large uterus occupying the entirety of a thin sac-like proglottis it is a reasonable assumption that such pores have originated independently several times and that therefore such a character is of but little phylogenetic importance. To accept the hypothesis of Nybelin, a hypothesis not substantiated by reference to facts, that four suckers can be homologised with two bothridia, auricular appendages with a terminal scolex plate, and a compact vitelline gland with a follicular sheath would abolish the present classification of the Cestoda without the suggestion of any substitute. It is easier to assume the displacement of a vitelline gland from a posterior, through a ventral, to an anterior position, a variability of the scolex within the family as shown by *Priapocephalus*, *Tetrabothrius* and *Anophryocephalus*, and a uterine pore, vestigial, but not to the point of complete disappearance as in the remainder of the Cyclophyllidea. The Tetrabothriidae are therefore considered as belonging to that order.

Parabothrium, placed by Nybelin in the Abothriinae, appears rather to have Tetraphyllidean affinities. The continuous follicular ventral layer (marginal according to Woodland, 1927 *a*, Pl. XIII, figs. 11–12) is paralleled by that in *Dinobothrium* (Woodland, 1927 *a*, Pl. XII, figs. 7–10, shows lateral vitellaria), the scolex may be regarded as of the same type as *Discocephalum*, while the anterior opening of the vagina with reference to that of the cirrus sac and the crossing of the two is a further Tetraphyllidean character. The genus should therefore be placed near *Dinobothrium* in that order. As has

already been mentioned, Baylis has noted the resemblance between *Tetrabothrius* and *Dinobothrium*. While probably transitional forms, the presence of bothridia and of a diffuse vitelline gland should place the latter in the Tetraphyllidea.

Tetrabothrius Rudolphi, 1819.

727. **T. dubius** n.sp. (Pl. XIX, fig. 1).

Host. Unknown.

Length 200, greatest breadth 1·0. Scolex 1·2–1·5 dia., with well developed acetabular appendages. Inner longitudinal muscle bands of 13–14 fibres, outer of 6–8. Testes 47. Genital papilla not well developed. Cirrus sac 0·077–0·089 long. Labelled *T. macrocephalus*. The above characters separate it from all other species except *T. catherinae* Leiper and Atkinson (1915, p. 51), the description of which is inadequate.

Species Insufficiently Known.

693. **Taenia** sp.

Host. *Recurvirostra avocetta*.

Length 2, greatest breadth 0·5. Scolex 0·22–0·27 dia. Rostellum 0·05 dia., with 8 hooks 0·044 long. Proglottides immature. Krabbe (1869, p. 53) records a hook 0·041 long from a cestode from this host and of a similar shape. Wolffhügel (1900, p. 138) considers Krabbe found two species, one *Diplophallus polymorphus* (Rudolphi, 1819) and one of another genus. The present form is identical with Krabbe's second species. As the internal anatomy is obviously unknown it is better to leave the species unnamed.

815. **Taenia** sp.

Host. Unknown.

A single scolex without rostellum or hooks. Proglottides absent.

Order TETRAPHYLLIDEA Carus, 1863.

This order, as classified by Braun (1894, p. 1684), included four families: Ichthyotaeniidae Ariola, 1899, Phyllobothriidae Braun, 1900, Onchobothriidae Braun, 1900, and Lecanicephalidae Braun, 1900, to which La Rue (1911) added a fifth, Monticelliidae, and Meggitt (1924, p. 143) a sixth, Polypocephalidae. During recent discussions, the Phyllobothriidae and Onchobothriidae have always been retained in the order, though Woodland (1927, p. 533) suggested their amalgamation by reason of the lack of any distinction except scolex characters: while agreeing with his main contention that the characters of the scolex are extremely liable to variation and therefore are of little systematic importance, it should be emphasised that this does not apply to the hooks. The shape of these can be of but little use, and will therefore probably persist unchanged, affording a means of determining relationships. The

families Davaineidae, Biuterinidae, Taeniidae, and Hymenolepididae each have hooks of a distinctive shape. Those of the Onchobothriidae are similarly of a characteristic shape not paralleled amongst the remainder of the Cestoda: according to precedent, the Onchobothriidae is thus a valid family. The families Ichthyotaeniidae and Monticelliidae, with the scolex bearing four true suckers, are obviously connecting links with the Cyclophyllidea. Southwell (1925, p. 13) includes them in that order in a special division, the Multivitellata, a classification not accepted by Woodland (1925, p. 188; 1927, p. 526). The characters of the scolex, exclusive of hooks, being more liable to variation, are of less importance than internal characters: the presence of true suckers is counteracted by the presence of a true Tetraphyllidean vitellarium, the Ichthyotaeniidae and Monticelliidae are therefore more closely allied to the latter. The validity of the Lecanicephalidae and the Polypocephalidae, accepted by Poche (1925, pp. 372, 375), is questioned by Woodland (1927, p. 535) whose contentions appear justified: the characters of the scolex alone, apart from hooks, are insufficient for the diagnosis of a family though, in the present case, in the absence of information regarding the internal anatomy, the families may be continued as purely practical expedients. Southwell's (1925, p. 248) device of including the Lecanicephalidae (synonym Polypocephalidae) in the Cyclophyllidea is untenable, the internal anatomy having nothing in common with that of that order, while the sucker-like nature of the phyllidea is dubious.

The relationships of the order itself, apart from those of its families, is a subject upon which authors have not agreed. Southwell (1925, p. 13), following Braun, recognises the order with the exception of the Ichthyotaeniidae and a new group, the Heterophyllidea, the latter, characterised by the absence of characters, being an expedient for the disposal of aberrant forms. As already stated, Baylis (1926, p. 172) has recognised its affinities, through *Dinobothrium*, with the Tetrabothriidae, a family considered by Braun, Fuhrmann and Meggitt to belong to the Cyclophyllidea, but by Poche and Nybelin to the Pseudophyllidea. Poche, carrying Southwell's idea still further, amalgamates (1925) the Cyclophyllidea and the Tetraphyllidea as two sub-orders of the order Taeniidea: Woodland (1927, p. 543), on the other hand, amalgamates the Tetraphyllidea and the Trypanorhyncha. Pintner (1928, p. 113) does not recognise any of the existing orders but subdivides the Cestoda *s.str.* into ten families: Bothriocephalidae, Echinobothriidae, Tetrarhynchidae, Tetraphyllidae, Proteocephalidae, Taeniidae, Discocephalidae, Tetragonocephalidae, Cephalobothriidae, and Balanobothriidae. In view of the variations in structure in the Taeniidae, undue importance appears to be placed upon the differences separating the last four families from the Tetraphyllidae. Eliminate these, with the exception of the separation of the Proteocephalidae—again a dubious procedure—and the classification is practically that of Braun.

The basis of classification of each of the above authors is different. South-

well relies wholly upon the characters of the scolex, characters entirely repudiated by Woodland: as already stated, the utilisation for classification of organs exceedingly liable to variation within the limits of a genus (*e.g. Phyllobothrium*) appears to the author untenable. Poche neglects to define the orders recognised by him: it is difficult to see the basis of classification when the following occur:

	Suckers	Bothridia	Vitelline gland	Uterus	Uterine pore	Genital pore	Order
Tetrabothrius	4	—	Compact	Sac	Present	Marginal	Pseudophyllidea
Diphyllobothrium	—	2	Follicular, concentric	Tube	Present	Surficial	Pseudophyllidea
Ichthyotaenia	4	—	Follicular, marginal	Tube with lateral branches	Absent	Marginal	Taenioidea
Taenia	4	—	Compact	Tube with lateral branches	Absent	Marginal	Taenioidea
Phyllobothrium	—	4	Follicular, marginal	Sac	? Absent	Marginal	Taenioidea
Crepidobothrium	4	—	Follicular, marginal	Sac	Present	Marginal	Taenioidea
Mesocestoides	4	—	Compact, double	Capsule	Absent	Surficial	Taenioidea

Woodland's definition of his order is "a Tetraphyllidean scolex..., marginal genital pores, longitudinally median saccular uteri, ventral uterine pores or slits or vestiges of such which appear as dehiscences, and dispersed, marginally- or concentrically-arranged, vitellaria." Of these, the follicular vitellarium and the ventral uterine pore alone separate it from the Cyclophyllidea. The existence of uterine pores in the Tetraphyllidea does not appear to occur to the extent postulated by him. Southwell (1925, p. 16) states: "A primary uterine pore, situated ventrally, is usually absent but may be present: a secondary uterine pore, or pores, due to atrophy of the body wall leading to dehiscence, occurs in some species in which true uterine pores are absent"; (p. 41): "In some of the writer's specimens, uterine pores were actually observed, but in all cases, transverse sections of gravid segments showed a great atrophy of the ventral wall." Woodland (*loc. cit.* p. 520) was unable to find pores, though later (pp. 527, 528, etc.) he describes uterine openings. To the author, judging from descriptions and figures only, these appear of the nature of splits similar to those found by him in gravid proglottides of *Ichthyotaenia* where pores are absent, a hypothesis partially substantiated by the statement (p. 530): "In the former species the uterus develops funnel-like outgrowths—which pierce the ventral subcuticula and open to the exterior —whereas in the latter species a similar single downgrowth (sometimes two) develops about midway in the uterus length, which then extends anteriorly and posteriorly until in the fully-ripe proglottid the uterus aperture is represented by a long slit coextensive with the uterus length." Apart from the accuracy of the diagnosis, it is clearly unwise to utilise (for the separation of important groups) characters the existence of which is still under consideration. Further, should the Tetrabothriidae be included in the Cyclophyllidea, the latter order has members (besides *Gyrocoelia*) with definite uterine pores: should it be placed in the Pseudophyllidea, the distinction between the two

regarding suckers breaks down. There remains simply the distinction of the vitellaria. (In parenthesis there is much to be said for such a classification as that of Janicki (1918) which divides the Cestoda *s.str.* into two orders based on that organ.) The differences separating the Tetraphyllidea and the Pseudophyllidea are (p. 541) marginal genital pores, an elongated saccular uterus associated with a Tetraphyllidean scolex: this involves the utilisation of a scolex character, a procedure entirely at variance with the opinions formerly expressed. A contradiction exists in the fact that a difference in scoleces is sufficient to separate *Abothrium* and the Tetraphyllidea, while the presence of proboscides is without the same importance. Follicular vitellaria are of significance in the separation of the Cyclophyllidea, but their distribution is useless for the other groups. The classification is not tenable.

In view of the lack of agreement amongst investigators as above outlined, and the contradictions inherent in the systems proposed, it is necessary to revert to the old classification of Braun. For the separation of all orders this employs the same characters, while only those are utilised which possess considerable systematic importance and to which exceptions are rare. The following orders are therefore recognised:

Cyclophyllidea—four true suckers, compact vitelline gland, single (but double in the Mesocestoididae).

Tetraphyllidea—four true or false suckers, vitelline gland follicular and marginal (*i.e.* in two lateral longitudinal bands).

Pseudophyllidea—two bothridia, vitelline gland follicular and concentric.

Trypanorhyncha—four true or false suckers, vitelline gland follicular and concentric, proboscides (except *Aporhynchus*) present.

A pseudoscolex or deformation of the scolex, with or without suckers, is present in all groups and is therefore disregarded.

Family ICHTHYOTAENIIDAE Ariola, 1899.

Corallobothrium Fritsch, 1886.

735. **C. solidum** Fritsch, 1886.

Host. *Malopterus electricus.*

Locality. Cairo.

The tube contained a few fragments too badly preserved and too densely pigmented to allow of detailed study.

Ichthyotaenia Lönnberg, 1896.

689 *b*. **I. sulcata** Klaptocz, 1906.

Host. *Sitta europaea.*

The specimens agreed with La Rue's description (1914, p. 162) except in the following points. Scolex simple, without furrows of any kind, 0·35 dia. Genital pore varied between the anterior quarter and the centre of the

proglottis margin. Vaginal pore usually posterior to but occasionally ventral or anterior to male pore. Testes 120–150. The record from this host is either due to confusion of labels or the record of a pseudo-parasite.

Family MONTICELLIIDAE La Rue, 1911.

Marsypocephalus Wedl, 1861.

784 *b*. **M. rectangulus** Wedl, 1861.

Host. *Heterobranchus anguillaris*.

Locality. Cairo.

Tube containing only a few fragments. Greatest length 9. In the same strobilus, scolex 0·73 dia.: breadth of posterior segment 0·25. Scolex devoid of any trace of apical organ. End proglottis broader than long. All immature. Genital pore at anterior third of proglottis margin. Cirrus sac apparently passing excretory vessels. The present identification is provisional, resting mainly on the massive character of the head as figured by Fuhrmann and Baer (1925, fig. 11).

Rudolphiella Fuhrmann, 1916.

818. **R. lobosum** (Riggenbach, 1896).

Label absent.

Family PHYLLOBOTHRIIDAE Braun, 1900.

Phyllobothrium Beneden, 1850.

664. **P. lactuca** Beneden, 1850.

Host. *Lamna* sp.

Tube containing numerous fragments and scoleces, all in an exceedingly bad state of preservation. Scolex varying from a large fleshy spherical organ, covered with a mass of bothridia with folded and crumpled margins, to a smaller elongated organ provided anteriorly with a number of apparently pinnately branched tentacles: intermediate stages were observed. This tentacle-like appearance of the suckers, due to bad preservation, raises the question whether similar structures described for such genera as *Polypocephalus* Braun, 1878, *Calycobothrium* Southwell, 1911, and *Anthemobothrium* Shipley and Hornell, 1906, may not be due to the same cause. Accessory suckers not seen. Cirrus sac large; extending half-way across and containing numerous coils of the vas deferens surrounded by a dense glandular mass: near the external end the lumen of the vas deferens suddenly expands to 5–7 times its former diameter and forms the eversible portion. A definite cirrus, in the sense of an armed stiff chitinous eversible tube, as in the Cyclophyllidea, is absent. Testes numerous: in one segment 545 were counted and probably many missed: completely filling proglottis and extending laterally to excretory vessels. Female glands not developed.

768. **P. riggii** (Monticelli, 1893).

Host. *Lamna* sp.

Locality. Suakim.

Numerous fragments, all devoid of any trace of genital organs. Scolex as figured by Monticelli (1893).

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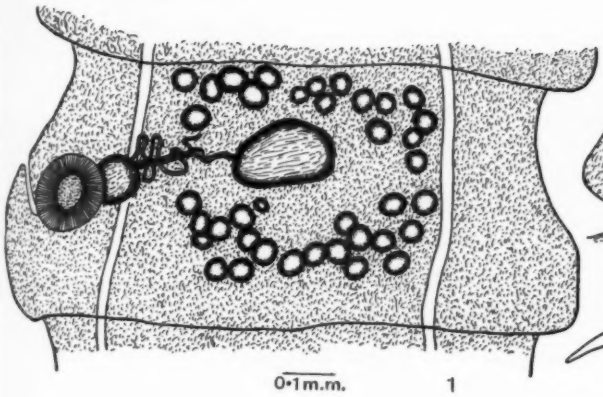
EXPLANATION OF PLATE XIX.

Fig. 1. *Tetrabothrius dubius* n.sp.
Fig. 2. *Cladotaenia secunda* n.sp.
Fig. 3. *Mesocestoides elongatus* n.sp.
Fig. 4. *Progynotaenia odhneri* Nybelin.
Fig. 5. *Taenia* sp.: rostellar hook.
Fig. 6. *T. triserrata* n.sp.: rostellar hook.
Fig. 7. *Progynotaenia flaccida* n.sp.: rostellar hook.
Fig. 8. *P. foetida* n.sp.: rostellar hook.
Fig. 9. *P. odhneri* Nybelin: rostellar hook.
Fig. 10. *Biuterina fallax* n.sp.

CORRECTION.

In the preceding paper (1927, *Parasitology*, **19**, 439 and 443) the names proposed for two new species, *Hymenolepis furcifera* and *H. pauciovata* are pre-occupied by *H. furcifera* (Krabbe, 1869) and *H. pauciovata* Fuhrmann, 1906 respectively. For *H. furcifera* is suggested the name *H. fungosa* and *H. fidelis* for *H. pauciovata.*

(*MS. received for publication* 25. vi. 1928.—Ed.)



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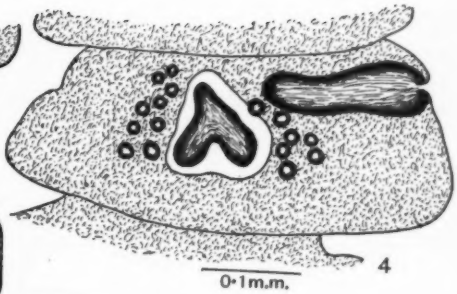

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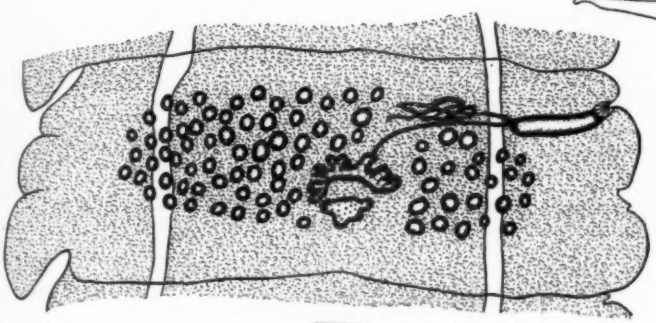

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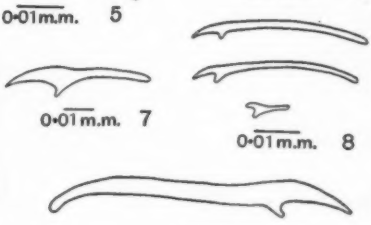

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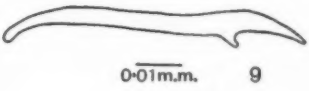

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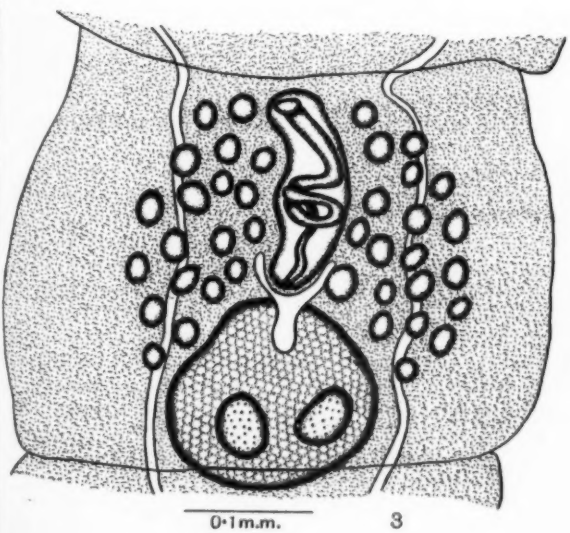

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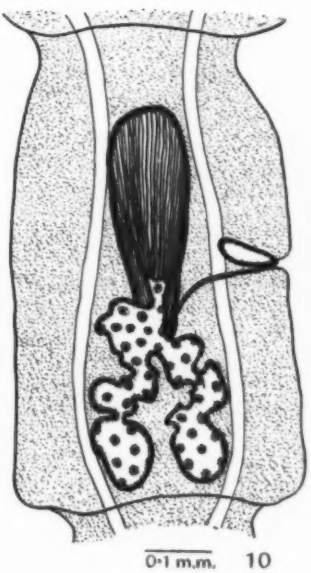

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UNIV. OF MICH.

A DESCRIPTION OF THE GENUS *CRENOSOMA* MOLIN, 1861 (METASTRONGYLIDAE, NEMATODA)[1].

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(With 15 Text-figures.)

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The genus *Crenosoma* was founded by Molin in 1861 for two species of nematodes, *Strongylus canis vulpis* Rud., 1819, from the lungs of a fox (*Vulpes vulpes* L.), and *Strongylus striatus* Zeder, 1800, from the bronchi of a hedgehog (*Erinaceus europaeus* L.).

From time to time these two species have been mentioned in helminthological literature under various names; but the correct name of Rudolphi's species according to the International Rules of Zoological Nomenclature must be *Crenosoma vulpis* (Dujardin, 1845) and that of Zeder's species *Crenosoma striatum* (Zeder, 1800).

We have found both species in several localities in Russia, *C. vulpis* occurring not only in the lungs of foxes but also in the lungs of wolves (*Canis lupus* L.) in the districts of Moscow and Severo-Dvinsk. In addition, a third representative of the genus has been found to occur in the lungs of *Kolonocus sibiricus* (Pall.), Mustelidae, in Russia. This parasite appears to constitute a new species to which we give the name *Crenosoma taiga*.

The genus *Crenosoma* now contains three species, each of which is represented in our collection by abundant material, and we propose to redescribe the old species, to compare them with *C. taiga*, and also to supply a generic diagnosis.

Genus **Crenosoma** Molin, 1861.

Diagnosis: Metastrongylidae; cuticle thrown into transverse ring-like folds, each carrying on its posterior border a fringe of fine thorns: folds may be present throughout or may be confined to the anterior portion of the body.

[1] We are indebted to Mr R. Daubney for his kind help in editing this paper.—Ed.

Mouth rounded, buccal capsule very much reduced. *Male*: bursa consisting of two large lateral lobes and a dorsal lobe, ventral rays parallel, externo-lateral arising separately from the other laterals, medio-lateral and postero-lateral parallel and closely applied to each other, externo-dorsal arising separately from the dorsal, which may be simple or provided near its tip with excrescences representing the accessory branches. Spicules equal, each bearing a dorsal process, accessory piece present. *Female*: vulva situated near the middle of the body, one pair of lateral caudal papillae. Viviparous.

Parasites of the respiratory tract of carnivores and insectivores.

Crenosoma striatum (Zeder, 1800).

Figs. 1–5.

HOST: *Erinaceus europaeus* L.

LOCATION: Bronchi.

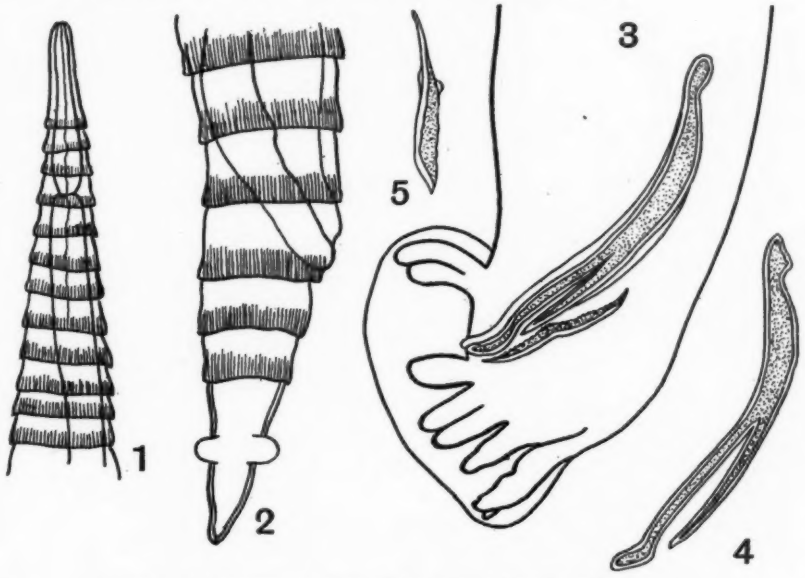
DISTRIBUTION: Europe.

Slender forms of a light yellow colour, tapering at each extremity. The cuticle at the anterior end of the male and throughout the whole surface of the female is thrown into a series of ring-like folds, producing an appearance of segmentation. The posterior margin of each fold overlaps the anterior portion of the next one and is furnished with a ring of minute spines pointing backwards. In addition the surface of the folds shows a light longitudinal striation. The mouth opens into a short cylindrical oesophagus, which extends for about one-twentieth part of the body-length in the male, and about one forty-third part in the female.

Male: from 5 to 6·75 mm. in length and about 0·24 mm. in maximum thickness. At the level of the base of the oesophagus the body is about 0·1 mm. in width. There are 18–20 cuticular folds which extend for a distance of about 1 mm. from the head. The structure of the bursa conforms to the usual characters of the genus. The externo-dorsal ray is short, while the dorsal carries two lateral projections near its tip. The spicules attain a length of 0·24 mm. and at the root are about 0·025 mm. thick. They are divided in the distal third into two branches, a slender dorsal one and a ventral one. The dorsal branch may be 0·1 mm. in length, and is rounded at its tip; the longer ventral branch is slightly curved distally and bent somewhat in the form of a crotchet at its free end. The triangular accessory piece is about 0·085 mm. in length.

Female: measures up to 12 or 13 mm. in length, and up to 0·34 mm. in maximum thickness in the region of the vulva. At the level of the base of the oesophagus the body may be up to 0·18 mm. in diameter. In the female, cuticular folds are present throughout the length of the body, extending even on to the tail; a character which serves at once to distinguish this species from the other known members of the genus. The tail is about 0·22 mm. long; it is bluntly conical with a rounded tip. Midway between the last cuticular fold and the tip of the tail is a pair of large lateral papillae. The vulva is situated in the

anterior half of the body, dividing it in the ratio 1 : 1·73. The eggs measure up to 0·082 × 0·048 mm. and contain a spirally-coiled embryo.



Figs. 1–5. *Crenosoma striatum* (Zeder, 1800). After Skrjabin (1916).

Fig. 1. Male, anterior extremity. Fig. 2. Female, posterior extremity. Fig. 3. Male, posterior extremity. Fig. 4. Spiculum. Fig. 5. Gubernaculum.

Crenosoma vulpis (Dujardin, 1845).

Figs. 6–10.

HOST: *Vulpes vulpes* and *Canis lupus* (new host).

LOCATION: Bronchi.

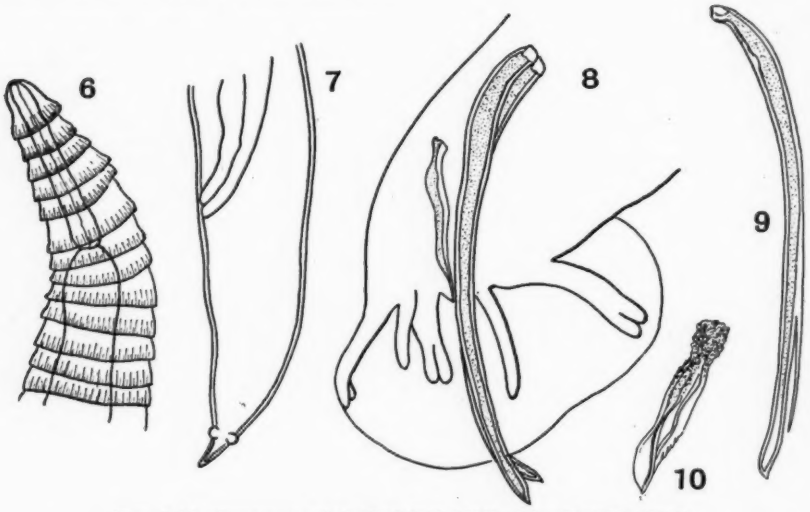
DISTRIBUTION: Europe.

Slender worms of a light yellow colour, tapering at each end. In both sexes the cuticle of the anterior portion of the body is provided with ring-like folds. The remainder of the body surface is smooth. The length of the oesophagus is equal to about one-fourteenth part of the body-length in the male and one thirty-seventh part in the female.

Male: from 3·5 to 5 mm. in length, with a maximum thickness of 0·28 to 0·3 mm. In the oesophageal region the body is about 0·17 mm. in diameter. The cuticular folds, 18 to 20 in number, extend for a distance of roughly 1 mm. from the anterior end. In the bursa the ventral rays are the longest of all; the externo-lateral is long and slender, the medio-lateral and postero-lateral are separated only in their distal portions and are faintly bifurcate at their tips. The externo-dorsal is short. The dorsal ray is provided with lateral projections near its tip, giving it a bifurcate appearance. The spicules are

0·37 mm. in length and 0·022 mm. in thickness near the root. In its distal third each spicule splits into two branches. The dorsal branch is slender and stilette-shaped and may attain a length of 0·1 mm.; the longer ventral branch, in reality a continuation of the main shaft of the spicule, is rod-like and slightly swollen at its tip. The accessory piece measures up to 0·55 mm. in length, and its ventral surface forms a gutter-like depression posteriorly. Dorsally the surface of the accessory piece is roughened in its anterior half.

Female: attains a length of from 12 to 15 mm. and is 0·3 to 0·46 mm. in maximum thickness. In the oesophageal region the body is about 0·22 mm. in thickness, and in the region of the vulva from 0·38 to 0·42 mm. The cuticular folds, 22 to 26 in number, extend for a distance of from 2 to 2·7 mm. from the anterior end of the worm. The tail of the female is about 0·87 mm. long and bears a pair of small lateral papillae close to its tip. The vulva divides the body-length in the ratio 1 : 1·08. The eggs measure up to 0·074 × 0·05 mm. and contain a spirally-rolled embryo.



Figs. 6–10. *Crenosoma vulpis* (Rudolphi, 1819). After Skrjabin (1916).
Fig. 6. Male, anterior extremity. Fig. 7. Female, posterior extremity. Fig. 8. Male, posterior extremity. Fig. 9. Spiculum. Fig. 10. Gubernaculum.

Crenosoma taiga n. sp.
Figs. 11–15.

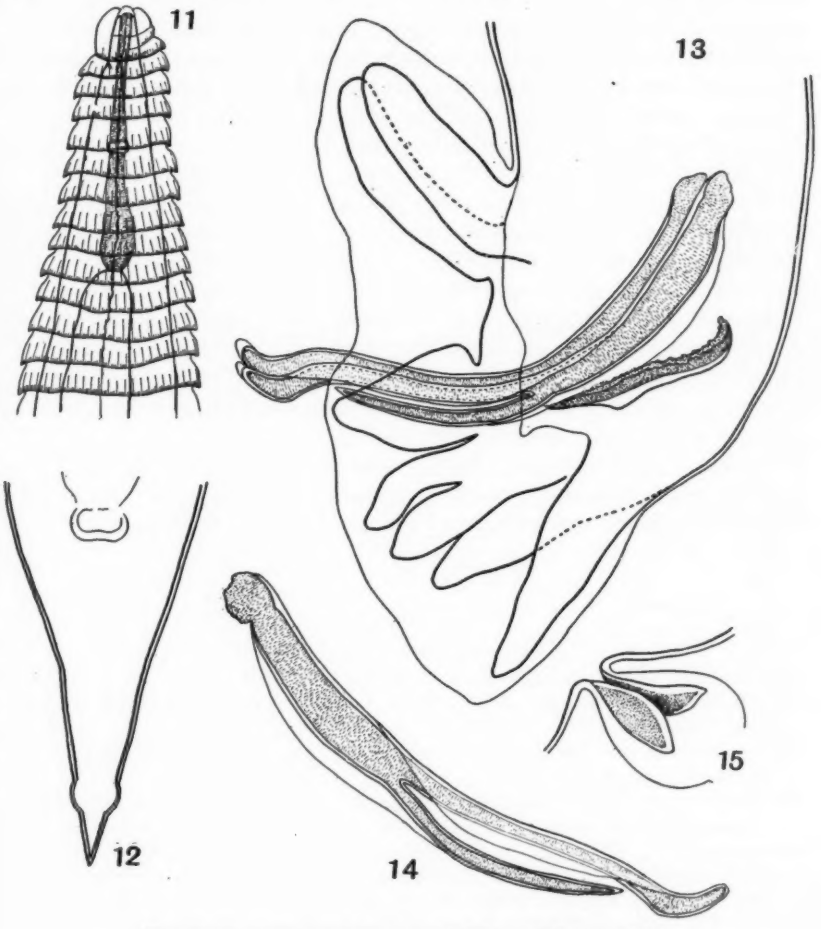
Host: *Kolonocus sibiricus* Pall.

Location: Bronchi.

Distribution: Asia (Siberia).

Slender worms, light yellow in colour and tapered towards either extremity. The cuticle of the anterior part of the body in both sexes is thrown into the usual transverse folds; posteriorly the cuticle is smooth. The length of the

oesophagus is equal to about one twenty-fourth part of the total body-length in the male and one twenty-fifth part in the female. An excretory pore is present at a distance of from 0·104 to 0·112 mm. from the anterior end.



Figs. 11–15. *Crenosoma taiga* n. sp. Skrjabin and Petrow, 1928.

Fig. 11. Female, anterior extremity. Fig. 12. Female, posterior extremity. Fig. 13. Male, posterior extremity. Fig. 14. Spiculum. Fig. 15. Vulva.

Male: attains a length of from 6·16 to 7 mm., with a maximum thickness of 0·317 in the middle third of the body. In the oesophageal region the body is about 0·118 mm. thick. The cuticular rings or folds extend for a distance of 2·15 to 2·35 mm. from the anterior end. The ventral rays of the bursa are the longest of all. The dorsal ray is smooth and shows no trace of lateral

accessory branches. The spicules, which are dark brown in colour, are from 0·286 to 0·294 mm. in length. The root of the spicule is tuberous and may be as much as 0·017 mm. in diameter. Behind its root each spicule is slightly constricted, broadening out later to a maximum thickness of 0·022 near the middle of its length, where it divides into a shorter dorsal branch and a longer ventral one. The dorsal branch is about 0·131 mm. long and is sharply pointed; the ventral branch, which is stouter, measures about 0·176 mm. and ends in a ventral crotchet-like projection. The spicules bear dorsal and ventral alae. The accessory piece is triangular in shape, about 0·129 mm. long and 0·106 mm. in maximum width.

Female: attains a length of about 13·7 mm., with a maximum thickness of 0·475 mm. in the middle region. At the level of the base of the oesophagus the body is approximately 0·229 mm. in diameter, in the region of the vulva 0·378 mm., and near the anus 0·081 mm. The cuticular rings, which are 0·052–0·056 mm. apart, extend for a distance of about 8·9 mm. from the anterior end. The tail is about 0·16 mm. in length; it is sharply pointed and bears a pair of lateral papillae near its tip. The vulva, which is in the form of a transverse slit, is provided with two chitinised plates. The vulva divides the body-length in the ratio 1 : 1·69. The eggs in the uterus measure 0·064–0·068 mm. × 0·034–0·036 mm. In the distal portion of the uterus and in the vagina one sees the fully-developed fusiform embryos, which are 0·269–0·289 mm. in length and 0·014–0·017 mm. in maximum thickness.

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(*MS. received for publication* 11. VII. 1928.—Ed.)

A REVIEW OF THE TELORCHIINAE, A GROUP OF DISTOMID TREMATODES.

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From the Zoological Laboratory, Cambridge.

(With Plates XX and XXI.)

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I. INTRODUCTION. HISTORY OF THE SUB-FAMILY.

The modern history of the group of parasites of which this paper relates begins with the unfortunate publication on the same day—December 28th, 1899—of two simultaneous revisions of the Trematoda by Looss and Lühe, which has led to endless confusion and difficulties of nomenclature. In the present instance both writers described new genera under the same name—*Telorchis*—placing in each somewhat similar assemblages of species, yet not sufficiently close in character to be accepted as synonymous genera; at the same time each writer wisely selected a type species and thereby rendered the task of unravelling this knot in systematics very much easier. The position will be

at once apparent on comparing the two descriptions, and in order to facilitate this I have rearranged the translated clauses of each so that they appear in the same order:

Telorchis Looss: Body elongated, more or less narrowed in front. Skin spinous or ? smooth. Intestine with pharynx, short oesophagus, and coeca reaching to the posterior end (of the body). ? Excretory vesicle. Genital aperture before the ventral sucker. Genital organs present, much elongated and reaching far posteriorly. Testes behind one another at the posterior end, ovary widely separated from them, somewhat lateral, lying near the end of the cirrus-sac. Laurer's canal present. ? Receptaculum seminis. Vitelline glands well developed, external to the intestinal coeca. Coils of the uterus not crossing to the outside of the coeca, and extending from the anterior testis almost to the coils of the cirrus-sac, very thick. Ova about 0·03 × 0·018 mm. Type: *T. linstowi* Stossich 1890, includes also *T. ercolanii* Monticelli 1893, *T. poireri* Stossich 1893, *T. nematoides* Mühling 1898, *T. arrectus* Molin 1859.

Telorchis Lühe: Spinous anteriorly. Oral sucker usually larger than the ventral sucker (except in *ercolanii* Monticelli, where they are of equal size). Intestinal coeca reaching the posterior end. Excretory bladder showing its elongated stem, bifurcating at the anterior end so that it appears Y-shaped. Testes median behind one another at the posterior end. Cirrus-sac exceptionally long and debouching in front of the ventral sucker. Ovary not median, near the end of the cirrus-sac, separated from the testes by the uterus which is strongly developed, whilst the vitelline gland fills the side of the body with numerous follicles, more or less approaching the anterior and posterior ends of the body. Type: *T. clava* Diesing 1851, includes also *bifurcus* Braun, *pleroticus* Braun, *arrectus* Molin, *poireri* Stossich, *ercolanii* Monticelli = *signatus* Ercolani nec Diesing, *nematoides* Mühling.

In 1900 Lühe pointed out that the two genera were incompatible inasmuch as *clava* Diesing, designated type of *Telorchis* Lühe, could not conform to *Telorchis* Looss. He therefore reaffirmed his own genus and founded a new genus—*Cercorchis*—for the residue. The two genera were separated as follows:

Telorchis Lühe 1900: Oesophagus absent. Uterine coils not confined within the intercoecal space. Type: *T. clava*.

Cercorchis Lühe 1900: Oesophagus present. Uterine coils confined within the intercoecal space. Type: *C. linstowi*.

The first hint of trouble with regard to these two genera was experienced with Braun who in 1901 placed *C. pleroticus* Braun and *C. bifurcus* Braun in the genus *Cercorchis* although they conformed only to the second clause (the uterus) and not to the first (oesophagus).

Now Looss had made his genus the type genus of a sub-family, and in 1909 Lühe accepted its claims and gave the following somewhat fuller definition of "Telorchiinae Looss":

"Medium-sized or small Distomids with elongated bodies, oval or round in cross-section and seldom flat. Skin spinous. Ventral sucker near the anterior

end, relatively small. Pharynx present, intestinal coeca long. Genital aperture very little before the ventral sucker, not quite median. Cirrus-sac exceptionally long, reaching far behind the ventral sucker. Ovary round, at the posterior end of the cirrus-sac, more or less before the middle of the body and usually lying out of the median line. Testes spherical, behind one another, the posterior (testis) at the end of the body, the anterior either in front of the former but not contiguous or behind the ovary and not contiguous with it. Laurer's canal present, likewise (usually?) a receptaculum seminis. Vitelline glands well developed, at the side of the body, lateral to the intestinal coeca. Uterus in numerous coils filling the whole space between the ovary and the testes behind, overlapping the anterior testis when it is forwardly situated. Eggs numerous, small. In the intestine of reptiles." This definition of the sub-family was adopted and quoted in translation by Ward and Whipple (1921).

In 1911 Barker and Covey added a third and very distinct genus—*Protenes*—to the group, but in 1916 Stunkard refused to accept Lühe's separation of *Telorchis* and *Cercorchis* and referred numerous newly-described species to the former genus. Stunkard was undoubtedly justified in this conclusion for his extensive material (all of which is referred to *Cercorchis* in the present work) provided him with species which presented a confined uterus but no oesophagus and also with oesophagate species whose uterine coils slightly overlapped the intestinal coeca; nevertheless, I do not think that he would have taken this step had he familiarised himself with Diesing's original description and figure of *D. clavum* for it is abundantly clear that two genera are needed. The rediscovery of *Telorchis clava* Diesing by Lühe in 1900 enabled him to describe the species fully, and in consequence we not only have to recognise *Telorchis* and *Cercorchis* as allied and distinct genera, but we also have to admit to their company others which show a more or less close resemblance to the former with the consequence that Lühe's definition of Telorchiinae Looss becomes no longer suitable. The net result is that the sub-family and two out of three perfectly valid genera must be redefined and that others must be added to the group.

II. DEFINITION OF THE SUB-FAMILY.

Telorchiinae Looss 1899.

Elongate Distomids, almost always spinous and rarely smooth. The ventral sucker lies in the anterior half of the body and neither sucker is remarkable for size. Anterior end simple, without para-oral lappets or processes. Pharynx present. The intestinal coeca extend to the end of the body or nearly to it. The chief excretory vessel is Y*-shaped with a long median stem and opens at the extreme posterior end or slightly dorsal to it. The cirrus-sac is well developed and its length exceeds the width of the ventral sucker in the known species. Testes behind one another, either diagonally placed or strictly in tandem, very rarely almost transverse. Laurer's canal and a receptaculum seminis are present. The ovary most often lies on the right side about the middle of the body or more forward, close to*

the ventral sucker or to the end of the cirrus-sac, and is separated from the anterior testis by coils of the uterus. The uterus is very well developed and fills the whole space between ovary and testes, but it does not pass down between the latter although it may occasionally overlap them more or less, the numerous eggs which it contains are rather small and are not arranged in single file. All the known species live in the intestinal tract of Reptiles and Amphibia.

The above definition differs from that given by Lühe in its omission of exact reference to the position of the genital aperture or to the extent and position of the vitelline glands and by not emphasising too much the length of the cirrus-sac (which, however, is extreme in some species) or its position with regard to the ventral sucker; these features are very variable in the group, though they present a very characteristic appearance in some forms, and if Lühe's description of them be retained very closely allied genera must be excluded. The position of the uterus in relation to the testes I regard as a very important point; the fact that the uterus does not make its way between the testes (even should they be separated) in its extreme extension, but presses at least one and most usually both back to the hinder end, whilst in the first place it develops backwards from the ovary so that this organ is not carried with it but remains in the neighbourhood of the cirrus-sac and the ventral sucker, is the root cause of the very characteristic arrangement of the reproductive organs which the most typical members of the group present; if it were not for this *locus* of the uterus we should have to admit the Plagiorchinae Lühe as allies of *Telorchis* Lühe. The fact that the ova are numerous, rather small, and crowded so that they never appear in single file within the uterus is the only reliable distinction from the Psilostominae Looss (parasites of water-birds) to which I can point, and it also excludes the majority of the genus *Opisthioglyphe* Looss 1899 but not the species hitherto known as *O. rastellum* Olsson which is a true member of the Telorchiinae closely allied to *Telorchis* Lühe[1]. The forward position of the ovary and the size of the cirrus-sac (which always exceeds the width of the ventral sucker) will distinguish the group from the Opisthorchiinae, Metorchiinae, and Omphalometrinae (parasites of mammals and birds) and more especially from the Azygiinae (parasites of fishes). The absence of expansions or processes beside the oral aperture differentiates them from the Auridistominae (in tortoises) and Bunoderinae (in fishes).

By the operation of these anatomical exclusions and inclusions we have left a group which exhibits some variety in the distribution of its vitelline glands, though they are always disposed in numerous discrete follicles, and in the position of the genital aperture with its contingent apparatus; nevertheless, the Telorchiinae thus constituted proves to be a very homogeneous

[1] The genus *Opisthioglyphe* was very incorrectly placed in the Plagiorchinae by Lühe (1909). All except *O. rastellum* and the other forms described below are best classified (anatomically) as of the Psilostominae—a group which characteristically lives among birds. They include parasites of mammals, birds, and snakes, as well as of amphibia.

group consisting almost exclusively of inhabitants of the small intestine of reptiles, the few exceptions affecting the Amphibia.

One of these related sub-families, however, is so similar in its occurrence and general appearance that confusion can hardly fail to occur with poor or preserved material and on this account must be given special consideration. No doubt the view that the Auridistominae (Ward, 1925), parasites in the intestines of water-tortoises, constitute a separate sub-family is correct, though I question whether their undoubted affinities with the Bunoderinae (Looss) have been taken into sufficient consideration. It is also open to question whether the presence of angular projections, more or less marked, beside the oral sucker will always be found to be a character sufficiently deep-seated and invariable to serve for the demarcation even of genera, and it may be decided in the future that some at least of these forms should be transferred to the Telorchiinae. At present, however, the group contains some species, such as *Pterygomaschalos chelydrae* (MacCallum, 1921), with large ova in single file within a relatively small uterus, whose position would be in doubt were their fellows to be transferred to the Telorchiinae. It seems best, therefore, to retain the Auridistominae as distinct, but they should not be forgotten by workers examining material which is supposedly Telorchiinae, and on this account I have appended a key and bibliography of the group.

The inclusion of the genus *Xenopharynx* Nicoll 1912 in the Telorchiinae by Khalil (1924) has been very properly criticised by Bhalerao (1926), and there is no doubt that it is correctly placed in the Lepodermatidae.

III. NOTES ON THE GENERA.

Cercorchis Lühe 1900.

As explained above, neither of the points on which this genus was originally founded provides a sound and valid distinction, but at the same time there is no doubt which species should be allied with *C. linstowi* Stossich as type of the genus. I think that the following definition will prove satisfactory in practice:

With the characters of the sub-family. Genital aperture close to and in front of the ventral sucker. Cirrus-sac exceedingly long and slightly coiled, the metraterm being about equally well developed and parallel to it. Testes in more or less strict tandem at the posterior end. Vitelline glands not extending in front of the ventral sucker or behind or over the testes, lateral to the intestinal coeca which usually bound the coils of the well-developed uterus. Type species: *C. linstowi* Stossich. The great majority of this large genus are species described from Chelonia, chiefly American water-tortoises, but two species live habitually in snakes and two in Amphibia.

Cercolecithos gen. nov.

I have raised this genus to include *C. arrectus* Molin 1859, a species which has never been rediscovered but of which there is an excellent description

from which it is clear that it corresponds to *Cercorchis* in all points save that the vitelline glands extend behind and over the testes. There is no sign of approach to this condition in any member of *Cercorchis* proper and since it is one of the chief points which distinguish this genus from *Telorchis* it must be allowed generic value. It is impossible to draw up a formal definition of the genus as yet, only one species being known with a probability that others will be added. The type species, *C. arrectus* Molin, was found in European lizards.

PROTENES Barker and Covey 1911.

This very distinct genus closely resembles *Cercorchis* in its general appearance, the arrangement of the reproductive organs, and in its very long cirrus-sac. The situation of the genital aperture very far forward on the margin (the left margin in the known species) of the body will at once distinguish it. Two species are known from American water-tortoises.

In the succeeding genera the cirrus-sac is much less uniform in bore and decidedly shorter, whilst the metraterm is less developed.

LECITHOPYGE gen. nov.

On re-examination of *Telorchis* I discovered that the species known as *Opisthioglyphe rastellum* Olsson agreed very closely with it save that its somewhat shorter cirrus-sac opened in the position usual for *Cercorchis*. There is therefore no question but that the species must be removed from *Opisthioglyphe* and given a place in the Telorchiinae. The position of the genital aperture is a character of generic significance throughout the sub-family and consequently we cannot place the worm in *Telorchis* Lühe; the following definition of a new genus is therefore proposed:

Lecithopyge gen. nov. *with the characters of the sub-family. Genital aperture close to and in front of the ventral sucker. Cirrus-sac variable in length but always exceeding the width of the ventral sucker and more or less coiled. Testes diagonally placed or almost in tandem and situated about midway between the ventral sucker and the posterior end of the body. Vitelline glands exceedingly well developed and filling the available space both in front of the ventral sucker and behind the testes. Uterus extending over the intestinal coeca.* Type species: *L. subulatum* (described below).

Three forms are known, all occurring typically in *Rana temporaria*, whose claim to the rank of species is somewhat doubtful, and it is possible that "*Monostomum hystrix*" of Molin (1861) in *R. esculenta* will also be found to belong to this group. The earliest described is by no means the most central form of the group.

TELORCHIS Lühe 1900.

As in the case of *Cercorchis*, Lühe's definition of this genus is quite unsatisfactory though he leaves no doubt of what it consists. I propose the following definition:

With the characters of the sub-family. Genital aperture somewhat distant from the ventral sucker, opening midway between it and the (*left in known species*)

margin of the body and rather advanced. Cirrus-sac variable in length. Testes oblique or nearly in tandem, midway between the genital aperture and the posterior end. Vitelline glands variable in development but in the known species they extend behind the testes. The uterus is well developed and passes across the intestinal coeca. Type species: *T. clava* Diesing.

This genus is very close to *Lecithopyge*, but is distinguished by the position of the genital aperture and the lesser development of the vitelline glands. Two species are known, both from the "anaconda" snakes of South America.

Dolichopera Nicoll 1914.

This genus was originally placed in the Lepodermatinae (or Plagiorchinae), no doubt on account of the diagonal position of the testes, but it is very evident from the published figures that the uterus does not pass down between the testes although it is so well developed as to overlap them. It differs from *Telorchis* Lühe only in the more transverse position of the testes, the more asymmetric position of the genital aperture which is usually found on the right anterior margin of the body (though it not infrequently occurs on the left), and in the more extensive uterus, all points of very relative importance. The genus is the Australian equivalent of *Telorchis*, for the two species occur in the snakes of that country.

In the two succeeding genera the genital aperture, though widely distant from the ventral sucker, is not asymmetrical but median or nearly so.

Dolichosaccus Johnstone 1912.

This genus and the succeeding were founded by Johnstone for the reception of certain species which showed a considerable resemblance to *Opisthioglyphe* (or rather the species *O. rastellum*) but differed in the longer cirrus-sac opening far forward. The present genus has the testes nearly in tandem and the uterus more or less confined to the intercoecal space, and therefore corresponds somewhat to *Cercorchis* or even more closely to *Cercolecithos*. Three or four species are known from Australian frogs. Another species placed in this genus—*D. parvula* Johnstone 1916—is known only by a single very young specimen (from the bird *Phalacocorax*) which has an exceedingly short uterus containing only one large egg, and which therefore should probably be removed to the Psilostominae.

Brachysaccus Johnstone 1912.

Differs from *Dolichosaccus* in its much larger uterus which exceeds the intestinal coeca and in the more thoroughly diagonal position of the testes. The genital aperture is also placed slightly more forward in the species described by Johnstone for it is found nearly over the pharynx instead of just behind the bifurcation of the intestine. Two species were described by Johnstone out of Australian frogs and a third was added by Nicoll (1918) apparently on the assumption that its immaturity prevented full display of the range of the uterus, though the only definite point in which it differs from *Dolichosaccus*

is the more forward position of the genital aperture; it seems to me very probable that the two genera are not really distinct and certainly they are more closely allied than any other two in the sub-family.

We are faced with a somewhat difficult problem in deciding which of the above genera is most typical of the sub-family. By right of precedence *Cercorchis* Lühe = *Telorchis* Looss and *Telorchis* Lühe 1899 *pars* ought to be chosen, but as a type-form it is rather too specialised in its metraterm and the disposition of its uterus. *Telorchis* Lühe 1900 is definitely out of the running on account of the position of its genital aperture. I believe the most central form to be *Lecithopyge* of European frogs for it forms a link between the frog and snake parasites of Australia and South America and the tortoise or amphibian parasites of the Palaearctic region, whilst its slightly asymmetric genital aperture foreshadows the tendency of this structure to wander from the neighbourhood of the ventral sucker. The casual coiling of the uterus in its simple expansion between ovary and testis, the less specialised cirrus-sac, and the scattering of vitelline follicles anywhere in the body that can provide sufficient space, are all anatomical points which seem to indicate that this is the most primitive form, a view which receives a certain support from its occurrence in Amphibia.

IV. NOTES ON PARTICULAR SPECIES. NEW SPECIES.

CERCORCHIS NECTURI sp. nov. (Pl. XX, fig. 1.)

It was the discovery of this species in the intestine of specimens of the well-known North American "newt" *Necturus maculatus* Raf. supplied by the Biological Laboratory at Wood's Hole and taken about the year 1923, where it was accompanied by an abundance of the tape-worm *Ophiotaenia lonnbergii* Führmann, and the attempt to establish its identity which led to the disclosure of the unsatisfactory condition of the group and the present review.

The only other species of the genus found in an amphibian is *C. stunkardi* Chandler 1923, from *Amphiuma*; the two worms are very distinct from each other although they share the common feature of the ventral sucker being larger than the oral, in all other species of the genus the oral sucker either exceeds the ventral (16 species) or the two are about equal (*solivagus* Odhner, *parvus* Braun, *bifurcus* Braun, *ercolanii* Monticelli).

C. necturi most resembles in its anatomy *C. corti* Stunkard 1916, a very variable species with the fairly extensive host range of three species of fresh-water tortoise, from which it may be distinguished by the relative size of the suckers, by the ovary lying closer to the cirrus-sac and separated by fewer coils of the uterus whose descending and ascending tracts may be crossed in *C. corti* instead of being quite distinct as in *C. necturi*, and by the relatively greater width of the ova. In all four specimens of *C. necturi* which I have examined the testes are remarkably pressed together and flattened transversely to the body, endowing the worm with a very characteristic appearance which distinguishes it immediately, but I hesitate to lay emphasis on a character

which may be an *artefact* resulting from the contraction which has followed an unsatisfactory death and fixation within the intestine of hosts preserved whole in formalin, especially since I have a specimen of *C. ercolanii* Monticelli killed in a similar manner which shows a slight tendency to flattening of the anterior testis; the posterior testis is slightly larger than the anterior, a point in which the worm agrees with *C. stunkardi* Chandler and differs from the majority of the genus.

The range of the various measurements in my four specimens is here given in millimetres:

Length 3·50–5·00, breadth 0·90–1·15, distance between the suckers 0·43–0·62, oral sucker 0·15–0·19 × 0·11–0·13, ventral sucker 0·17–0·20 × 0·17–0·20, prepharynx (absent), pharynx 0·09–0·12 × 0·08–0·11, oesophagus 0·09–0·17, cirrus-sac (length of intromittent section) 0·60–0·82, cirrus-sac (length of prostatic section) 0·80–1·25, metraterm 0·70–0·90, ovary 0·20–0·30 × 0·14–0·21, anterior testis 0·38–0·43 × 0·17–0·20, posterior testis 0·37–0·43 × 0·17–0·27, vitelline follicles 0·04–0·11 × 0·02–0·05, ova 0·020–0·034 × 0·016–0·026, spines 0·006–0·016. In all cases the longitudinal dimension is given first.

C. necturi sp. nov. Definition of the species.

A somewhat broad spinous species with the oral sucker smaller than the ventral, the ratio being about 3/4. Prepharynx absent, oesophagus present. Genital aperture displaced a little to the left. Cirrus-sac and metraterm large and well developed, slightly coiled. Ovary separated from the end of the cirrus-sac by one or two coils of the uterus which is confined by the intestinal coeca and is disposed in clear descending and ascending tracts, not mingled. The vitelline glands are somewhat asymmetrical, the right being less well developed and placed further forward, they extend to midway between ovary and ventral sucker in front and fall far short of the anterior testis behind. Testes ? transversely compressed, the anterior being slightly the smaller.

Average dimensions: size 4·25 × 1·01, *distance between suckers* 0·56, *oral sucker* 0·172 × 0·115, *ventral sucker* 0·190 × 0·185, *pharynx* 0·100 × 0·099, *oesophagus* 0·120, *cirrus-sac* (*length of intromittent section*) 0·75 + (*length of prostatic section*) 1·11, *metraterm* 0·81, *ovary* 0·18 × 0·26, *anterior testis* 0·18 × 0·41, *posterior testis* 0·23 × 0·40, *vitelline follicles* 0·073 × 0·029, *spines* 0·011, *ova* 0·0278 × 0·0195 mm.

Inhabits the small intestine of *Necturus maculatus* Raf., America.

The type specimen, from which Fig. 1 was drawn, has been deposited in the British Museum, co-types have been presented to the American National Museum and to the Molteno Institute for Research in Parasitology, Cambridge.

C. Ercolanii Monticelli 1893 (Pl. XX, fig. 2).
C. Ercolanii Stossich 1904.

Some doubt appears to have been felt in the past as to whether this species from the small intestine of *Tropidonotus natrix* L. is really distinct from *C. nematoides* Braun 1891. The species was redescribed by Stossich in 1904

and certain differences were tabulated, but these appear to be of a rather inconclusive character and depend chiefly on relative dimensions.

The worm is exceedingly common in grass-snakes from the more humid districts of Cambridgeshire, and I had noted it as distinct from *C. nematoides* Braun before I became aware of the existence of *C. ercolanii* as a described species. Although there is a general resemblance through the long narrow form and disposition of the reproductive organs in each, the two worms are very different. *C. ercolanii* most closely resembles *C. medius* Stunkard of American tortoises, with which it is practically identical in appearance, and the only distinguishing points are that in *C. ercolanii* the genital aperture is not displaced to the left but median, the vitelline follicles tend to be disposed in groups, and the dimensions of the ova are two-thirds those of *C. medius*. *C. nematoides* Braun is a narrower worm with the oral sucker larger and the pharynx smaller, the cirrus-sac is relatively larger than in any other species of *Cercorchis* and extends behind the ovary with which it is in contact instead of being separated by coils of the uterus as in *C. ercolanii*, the coils of the uterus are mingled and not disposed in clear descending and ascending tracts, the vitelline glands are not at all arranged in groups, the ovary is relatively smaller, and the ova are much larger and darker in colour when mature; I have never found *C. nematoides* in England. The figures of *C. ercolanii* given by Monticelli and Stossich convey no impression of the real appearance of the worm and but few measurements have been published, I have therefore supplemented the existing descriptions with Fig. 2 and the following list of dimensions:

Range of eight mature specimens:

Length 4·3–6·5, breadth 0·4–0·7, distance between suckers 0·6–1·25, oral sucker 0·09–0·16 × 0·09–0·14, ventral sucker 0·11–0·15 × 0·10–0·17, prepharynx 0·06–0·10, pharynx 0·06–0·105, oesophagus 0·16–0·30, cirrus-sac (length of intromittent section) 0·45–0·8 + (prostatic section) 0·6–1·2, metraterm length 0·6–1·1, ovary 0·09–0·18 × 0·10–0·26, anterior testis 0·17–0·26 × 0·13–0·29, posterior testis 0·18–0·27 × 0·12–0·30, vitelline follicles 0·016–0·050 × 0·012–0·030, spines 0·005–0·012, ova 0·022–0·036 × 0·014–0·018.

Average dimensions: size 4·96 × 0·54, distance between suckers 0·926, oral sucker 0·122 × 0·119, ventral sucker 0·122 × 0·126, ratio of oral to ventral sucker 0·934, prepharynx 0·075, pharynx 0·087, oesophagus 0·253, cirrus-sac length (intromittent section) 0·61 + (prostatic section) 0·83, metraterm length 0·78, ovary 0·128 × 0·166, anterior testis 0·191 × 0·198, posterior testis 0·226 × 0·194, vitelline follicles 0·031 × 0·019, spines 0·009, ova 0·027 × 0·016 mm.

The specimen of *C. ercolanii* Mont. from which Pl. XX, fig. 2, was drawn is now in the British Museum, other specimens on which the present description is based have been deposited in the American National Museum, the Molteno Institute for Research in Parasitology, and the Local Fauna Collection of the Cambridge Natural History Society.

LECITHOPYGE mihi.

When Looss (1906) discovered that a worm which he had incorrectly described as *Opisthioglyphe ranae* Fröhlich was not in fact such but closer to *L. rastellum* Olsson 1875, and that specimens sent to him from Cambridgeshire agreed with his own in this, all the worms were immediately dubbed *O. rastellum* Olsson. We have seen above that they are not *Opisthioglyphe* at all and it remains to be observed that the Cambridgeshire worms differ from *rastellum* Olsson in some important particulars which have been overlooked by Looss; not only is the general shape different, being fusiform in the Swedish species, whilst British specimens are almost always somewhat pyriform from their greatest width coming before the middle as appears very characteristically in Looss' figure, but the ova are considerably larger, the genital aperture is less displaced to the left with the apertures of the two sexes scarcely separated, and the cirrus-sac is about 2½ times as long as the width of the ventral sucker being sigmoid instead of falciform or crescentic and but little exceeding the width. These differences are such as to prevent assignation of the Cambridgeshire specimens to Olsson's species until the Swedish form is rediscovered and the original author's already very clear and detailed description is either confirmed or corrected, and I might have taken the course of describing a new species were it not for the possession of a specimen of unknown locality which differs almost as much from *rastellum* and the Cambridgeshire specimens as they do from each other, and for the fact that specimens from *Bufo vulgaris* Laur. also exhibit minor differences from the same form as it occurs in *Rana temporaria* L. It is evident, therefore, that *L. rastellum* Olsson is a very variable form capable of developing considerable differences when isolated by either locality or host, and I shall adopt the plan of describing three geographical races on the trinomial system now universally adopted in systematics of the higher vertebrates.

A fourth form, which has been adopted by Nicoll (1926) as the synonym with priority of *rastellum* Olsson, was described by Molin (1861) as *Monostomum hystrix* occurring in *R. esculenta* of North Italy. Molin, however, described this as definitely a *Monostomum* though the ventral sucker is clear enough in *rastellum* and he drew the near-by cirrus-sac quite well, he also described and figured two separate paired sets of vitellaria, an outer and a smaller inner set, with a lacuna between which has not the appearance of *rastellum* even when compressed; the dimensions of the ova were not given, but in the figure they seem to be very much larger than in the other three forms, the uterus, moreover, scarcely encroaches on the ovary as it is drawn but pushes more towards the opposite side of the body. It would be unwise therefore to adopt this name for the species until it has been rediscovered and properly appraised, yet the suggestive character of the whole figure and the nature of the host together with the similarity of the spinulation justify our retaining it as a probable but insufficiently described member of the present genus. The shape of the body, which in *hystrix* is broadly rounded

posteriorly and widest behind the middle, and the majority of its characters suggest that the form here described as *rastellum cylindriforme* is intermediate between Molin's species and the other two forms; in order to facilitate comparison, tables of dimension and proportion are given here.

(All dimensions given in millimetres)

	Sweden (according to Olsson)	Cambs. and Herts. From *Rana temporaria* (av. of 10)	Cambs. and Herts. From *Bufo calamitas* (av. of 2)	Unknown—(Herts. or France) From *R. temporaria* (1 specimen)	North Italy From *Rana esculenta* (from Molin's figure)
Length	4·0	3·48	2·90	4·50	5·3
Breadth	1·0	0·93	0·64	1·25	1·8
Between suckers	?	0·78	0·64	1·00	1·8
Oral sucker	0·35	0·31 × 0·33	0·28 × 0·26	0·37 × 0·38	0·48 × 0·39
Ventral sucker	0·25	0·24 × 0·25	0·185 × 0·19	0·29 × 0·29	?
Pharynx	0·19	0·20	0·15	0·24	0·53
Oesophagus cirrus-sac	?	0·08	0·07	0·10	
(Length of intromittent section)	0·40	0·25	0·20	0·35	0·70
(Length of prostatic section)	(greatest figured)	0·34	0·275	0·35	
Ovary	0·23 × 0·25	0·26 × 0·25	0·20 × 0·21	0·37 × 0·35	0·35 × 0·37
Vesicula seminalis	?	0·20	0·18	0·25 × 0·10	?
Anterior testis	0·31 × 0·38	0·26 × 0·29	0·19 × 0·25	0·35 × 0·37	0·50 × 0·62
Posterior testis	0·38 × 0·42	0·31 × 0·30	0·24 × 0·27	0·42 × 0·45	0·55 × 0·55
Vitelline follicles	?	0·043	0·043	0·075	?
Spines (av. length)	0·010	0·010	?	?	?
Spines (av. interval)	?	0·012	0·007	0·006	?
Ova	0·036 × 0·020	0·040 × 0·023	0·043 × 0·026	0·055 × 0·033	Large

The relationship between the five forms is well seen in the size of the ova and in the following series of ratios:

Oral sucker/ventral sucker	1·40	1·31	1·49	1·29	?
Oral sucker/pharynx	1·84	1·60	1·80	1·56	?
Length/length of cirrus-sac	10·0	5·9	6·1	6·4	7·0
Ventral sucker/length of cirrus-sac	0·625	0·415	0·400	0·415	?
Length/length between suckers	3·5	3·7	4·5	4·5	3·25

If the various forms be arranged in an order for the size of ova, or any of the several ratios, it will be seen that the two forms from East Anglian frogs and toads fall in contiguity with one another with regard to every feature save the ventral sucker, I therefore conclude that these two forms are not really distinct and that the geographical races differ more markedly from one another. For these geographical races I propose the following names and definitions:

L. RASTELLUM RASTELLUM (Olsson 1875) (Pl. XXI, fig. 4).

Fusiform, with the greatest width about the middle. Genital aperture well on the left of the ventral sucker and hardly in advance of it, the apertures of the two sexes being somewhat separated. Cirrus-sac not much longer than the ventral sucker, with its single curve having the concave surface directed to the right.

4·0 × 1·0, ova 0·036 × 0·020 mm.

Inhabits the small intestine of *Rana temporaria* L. and more rarely *Bufo vulgaris* Laur., Sweden.

L. RASTELLUM SUBULATUM subsp. nov. (Pl. XXI, fig. 3).

More or less pyriform, with the greatest width before the middle and rather sharply attenuated behind. Genital aperture close in front of the ventral sucker, sometimes displaced a little to the left, and with apertures of the two sexes only occasionally a trifle separated. Cirrus-sac two to three times as long as the ventral sucker, sigmoid, with the concave side of the first curve facing left.

(1) Suckers relatively smaller, spinulation not so close. 3·48 × 0·93, ova 0·040 × 0·023 mm. Abundant in the small intestine of *Rana temporaria* L., Cambridgeshire and Hertfordshire.

(2) Suckers, especially the oral sucker, relatively larger, spinulation relatively more close. 2·90 × 0·64, ova 0·043 × 0·026 mm. From the small intestine of *Bufo vulgaris* Laur., Hertfordshire.

L. RASTELLUM CYLINDRIFORME subsp. nov. (Pl. XXI, fig. 5).

A very large form of uniform transverse diameter, which is not pointed and is scarcely attenuated posteriorly. The suckers, especially the oral sucker, are relatively smaller. The cirrus-sac resembles that of L. subulatum *described above. The vitelline follicles are relatively much larger. The ova are larger. The spinulation is much closer.*

4·50 × 1·25, ova 0·055 × 0·033 mm.

A single specimen, taken from the small intestine of *Rana temporaria* of unknown origin but believed to be either France or Hertfordshire.

"MONOSTOMUM HYSTRIX (Molin 1861)." (? LECITHOPYGE)

A large species, not attenuated posteriorly but broad and even widened. Genital aperture somewhat displaced to the left of the median line, cirrus-sac intermediate in length with its concavity to the left "shaped like a cornucopia."

4·0–6·5 × 2·2 mm. *? Ova very large.*

Inhabits the small intestine of *Rana* (*Pelophylax*) *esculenta* L., on one occasion as many as thirty in one host, Patavii, North Italy.

The type specimen of *L. rastellum subulatum* from which Fig. 3 *A* was drawn by camera lucida has been deposited in the British Museum, and co-types have been sent to the Molteno Institute for Research in Parasitology, the Local Fauna Collection of the Cambridge Natural History Society, and the American National Museum.

V. A KEY FOR DETERMINING THE SPECIES OF TELORCHIINAE.

The inclusion of a described form in the following key by no means implies that I assent to its claim of specific status; the species described by Macallum (1918) from *Chelopus*, for example, seem to me very doubtful and require re-examination of the material, whilst I feel sure that more than one species has been called *C. aculeatus* Braun.

It should also be observed that a table such as this can only be based on those characters which happen to have been published by the several authors,

and its arrangement therefore depends more or less on the completeness of the details supplied, hence it must not be regarded as indicating the relationships of the forms concerned.

Distomid flukes with simple unbranched intestine and testes, with a follicular vitelline system, with a pharynx, cirrus-sac, receptaculum seminis, Laurer's canal, and Y*-shaped main excretory vessel opening at the posterior end, with the ovary in front of both testes and separated from them by one or more coils of the uterus.*

A. Anterior end simple, without expansions or processes around or beside the oral sucker.
   1. Ova numerous and relatively small, contained in a well-developed uterus wherein they are packed closer than in single-file. (In the intestine of reptiles and amphibia.) **Telorchiinae**
   2. Ova large and relatively few, contained in a uterus of relatively poor development wherein they are found in single-file. (In the intestines of water-birds.) **Psilostominae**

B. Anterior end complex, with processes, expansions, or a differentiated area bearing large spines around the oral sucker.
   1. Juxta-oral equipment not spinous, consisting of two lateral expansions only. (In the intestines of fresh-water and marine tortoises.) **Auridistominae**
   2. Juxta-oral equipment not spinous, consisting of five or six processes. (In the intestines of fishes.) **Bunoderinae**
   3. Juxta-oral equipment with specialised spines, larger than those of the general body-covering. (In the intestines of birds.) **Echinostomidae,** pars

TELORCHIINAE.

(60) 1. Genital aperture close to the ventral sucker.
(51) 2. Vitellaria not extending in front of the ventral sucker. Uterus normally confined to the intercoecal space.
(50) 3. Vitellaria not extending behind or over the testes. Testes in tandem. Cirrus-sac and metraterm long and more or less parallel. Gen. **Cercorchis**
(9) 4. Oesophagus absent.
(8) 5. Prepharynx very long. Vitellaria hardly extending so far as the ovary in front.
(7) 6. Descending and ascending uterine tracts mingled. Cirrus-sac contiguous with ovary. Spinous. 7·0 × 3·4 mm. Chelonian host: "Freshwater Tortoise" (Brazil). **C. pleroticus** (Braun 1891)
(6) 7. Descending and ascending uterine tracts distinct. Cirrus-sac separated from ovary. Spinous. 11·5 × 1·5, ova 0·023 × 0·014 mm. Chelonian host: "Freshwater Tortoise" (Brazil). **C. bifurcus** (Braun 1891)
(5) 8. Prepharynx very short. Vitellaria extending beyond the ovary in front and sometimes over the intestinal coeca. Uterine tracts distinct. Spinous. 6·0 × 0·95 mm. Chelonian host: *Cistudo carolina* (N. America). **C. robustus** Goldberger 1911
(4) 9. Oesophagus present. Vitellaria reaching at least the level of the ovary in front.
(47) 10. Intestinal coeca extending behind the posterior testes.
(32) 11. Prepharynx present.
(29) 12. Oesophagus short, not equal to the oral sucker, prepharynx and pharynx together.
(18) 13. Cirrus-sac longer, contiguous with the ovary, the latter lying in front of the mid-point of the vitelline range.
(17) 14. Vitellaria extending nearly or quite to the anterior testis. Oral sucker largest.
(16) 15. Oesophagus shorter than the pharynx. Vitellaria never extending over the intestinal coeca. Spinous. 9·5 × 1·05, ova 0·029 × 0·015 mm. Chelonian host: *Chrysemys elegans* (N. America). **C. robustus** (Stunkard 1916)

(15) 16. Oesophagus longer than the pharynx. Spinous. Dimensions not given. Chelonian host: *Chelopus insculptus* (N. America). **C. chelopi** (MacCallum 1918)

(14) 17. Vitellaria not reaching the anterior level of the testes. Ventral sucker largest. Spinous. 4·5 × 0·63 mm. Amphibian host: *Amphiuma micans* (N. America). **C. stunkardi** (Chandler 1923)

(13) 18. Cirrus-sac shorter, widely separated from the ovary, the latter lying about the mid-point of the vitelline range. Spinous. 9·2 × 0·93, ova 0·030 × 0·0125 mm. Chelonian host: *Chrysemys marginata* (N. America). **C. attenuatus** Goldberger 1911

(12) 19. Oesophagus equal to or larger than oral sucker, prepharynx, and pharynx together.

(31) 20. Descending and ascending uterine tracts distinct, except occasionally at the posterior end in *C. ercolanii*.

(28) 21. Beginning of cirrus-sac contiguous with ovary.

(27) 22. Vitellaria extending to or near the anterior level of the testes.

(26) 23. Oesophagus longer.

(25) 24. Genital aperture ? not spinous at margin. Spinous. 8·0 × 1·0, ova 0·050 × 0·030 mm.[1] Chelonian host: *Chelopus guttatus* (N. America). **C. guttati** (MacCallum 1918)

(24) 25. Genital aperture spinous at margin. Spinous. 4·5 × 0·8, ova 0·050 × 0·030 mm.[1] Chelonian host: *Chelopus insculptus* (N. America). **C. insculpti** (MacCallum 1918)

(23) 26. Oesophagus shorter. Ovary lying before the mid-point of the vitelline range. Spinous. Dimensions not given. Chelonian host: *Chelopus insculptus* (N. America). **C. chelopi** (MacCallum 1918)

(22) 27. Vitellaria ending well before the anterior level of the testes. Not spinous. 7·0 × 0·5 mm. Chelonian host: *Chelopus insculptus* (N. America). **C. pallidus** (MacCallum 1918)

(21) 28. Cirrus-sac separated from ovary.

(30) 29. Genital aperture displaced to the left. Vitellaria not divided into groups. Spinous. 4·14 × 0·41, ova 0·043 × 0·021 mm. Chelonian host: *Aromochelys odoratus* (N. America). **C. medius** (Stunkard 1916)

(29) 30. Genital aperture median. Vitellaria arranged more or less in groups. Spinous. 3·5 × 0·5, ova 0·027 × 0·016 mm. Ophidian hosts: *Tropidonotus natrix* and *T. viperinus* (Europe). **C. ercolanii** (Monticelli 1893) = *D. signatus* Ercolani nec Diesing

(20) 31. Uterine tracts mingled. Cirrus-sac very long, extending posterior to the ovary. Spinous. 3·5 × 0·85, ova 0·033 × 0·019 mm. Ophidian host: *Tropidonotus natrix* (Europe). **C. nematoides** (Mühling 1898)

(11) 32. Prepharynx absent.

(40) 33. Descending and ascending uterine tracts distinct.

(37) 34. Cirrus-sac contiguous with ovary.

(36) 35. Testes spherical, not lobed. Spinous. **C. linstowi** (Stossich 1890) = *aculeatus* (Braun 1891)

(*a*) Oesophagus nearly equal to the oral sucker and prepharynx combined, the latter being relatively smaller. Intestinal coeca somewhat shorter behind the testes which are more or less separated. Vitellaria extend well in front of the ovary. 5·0 to 10·0 × 0·5 to 1·0, ova 0·046 × 0·019 mm. Chelonian host: *Testudo graeca* (Europe). (TYPE, Braun 1891)

[1] The dimensions given by MacCallum (1918) for the ova of *C. guttati* Mac. and *C. insculpti* Mac. are five by three microns in each case, or ten times smaller in each dimension than is usual in the genus. This has appeared to me so inconceivably outside the range of ova size in the group that I am confident of some clerical error on MacCallum's part and have assumed that his "microns" represent ten microns as usually understood.

(*b*) Smaller than the type, with a slightly shorter oesophagus and relatively larger ovary. 3·0 to 4·0 mm. Chelonian host: *Chelydra serpentina* (N. America). (Goldberger 1911.)

(*c*) Oesophagus very short, hardly equal to the pharynx which is relatively larger, intestinal coeca rather longer behind the testes which are contiguous. Vitellaria hardly extend in front of the ovary. Ophidian host: *Tropidonotus grahami* (N. America). (Stunkard 1916.)

(*d*) A form attributed to *C. aculeatus* but with rounded posterior end, spherical testes, and ova 0·029 × 0·019 mm. (Relatively wide ova such as these are more characteristic of *Telorchis* and *Dolichopera*, typically Ophidian-living genera, than any form of *Cercorchis*.) Ophidian host: *Tropidonotus natrix* (Europe). (Looss 1899, p. 567.)

? Oesophagus present, oral sucker larger than ventral. Spinous. An immature specimen said to be more like *C. aculeatus* (*linstowi*) than *C. parvus* Braun, *C. poireri* Stossich, *C. pleroticus* Braun, or *C. bifurcus* Braun. 1·1 × 0·24 mm. Chelonian host: *Dermatemys marii* (India). **C. sp. inq.** (Heymann 1905)

(35) 36. Testes lobed. Oesophagus longer than oral sucker and pharynx combined. Spinous. 2·2 × 0·32, ova 0·034 × 0·0185 mm. Chelonian host: *Chelydra serpentina* (N. America). **C. lobosus** (Stunkard 1916)

(34) 37. Cirrus-sac separated from the ovary by a portion of uterus.

(39) 38. Oesophagus shorter. Ventral sucker largest. Cirrus-sac nearly touches ovary. Testes readily compressed. Spinous. 5·5 × 0·55, ova 0·027 × 0·016 mm. Amphibian host: *Necturus maculatus* (N. America). **C. necturi** mihi

(38) 39. Oesophagus longer. Oral sucker largest. Cirrus-sac widely separated from ovary. Testes spherical. Spinous. 5·6 × 0·4, ova 0·026 × 0·014 mm. Chelonian hosts: *Malacoclemys leseurii*, *M. geographicus* and *Chrysemys elegans* (N. America). **C. corti** (Stunkard 1916)

(33) 40. Uterine tracts more or less crossed and mingled.

(44) 41. Ovary lying before the mid-point of the vitelline range.

(43) 42. Uterine tracts partly crossed once only. Oesophagus shorter. Vitellaria extending further anteriorly. Spinous. **C. corti** (Stunkard 1916). (See above)

(42) 43. Uterine tracts crossed more than once. Vitellaria extend further anteriorly.

(41) 44. Ovary lying at or behind the mid-point of the vitalline range.

(46) 45. Uterine tracts crossed once only. Ventral sucker the largest. Cirrus-sac long and coiled, contiguous with ovary which lies at the mid-point of the vitelline range. Spinous. 7·5 × 0·9, ova 0·030 × 0·015 mm. Chelonian host: *Chlemmys caspica* (Europe). **C. solivagus** (Odhner 1902)

(45) 46. Uterine tracts crossed more than once. Oral sucker the largest. Cirrus-sac short and more or less straight. Ovary lies behind the mid-point of the vitelline range. Not spinous. 10·0 × 0·9 mm. Chelonian host: *Emys orbicularis* (Europe). **C. stossichi** Goldberger 1911 = *poireri* Stossich 1904 nec 1895

(10) 47. Intestinal coeca ending between the testes, not passing behind them.

(49) 48. Prepharynx present. Oesophagus shorter. Uterine tracts crossed and mingled. Vitellaria extending well in front of the ovary and nearly to the ventral sucker. Not spinous. 10·5 × 0·9, ova 0·028 × 0·018 mm. Chelonian host: *Emys orbicularis* (Europe). **C. poireri** Stossich 1895 = *gelatinosum* Poirier nec Rudolphi

(48) 49. Prepharynx absent. Oesophagus longer. Uterine tracts distinct. Vitellaria not extending to the ovary. Not spinous. 2·0 × 0·34, ova 0·041 × 0·023 mm. Chelonian host: *Emys orbicularis* (Europe). **C. parvus** (Braun 1901)

(3) 50. Vitellaria extending posterior to the testes. (Compare with Auridistominae 3.)

(52) 51. Coils of the uterus in distinct ascending and descending tracts. Genital orifice median. Cirrus-sac extending posterior to ovary. Vitellaria joined in a band over

testes. Prepharynx absent. Oesophagus present. Spinous. 3·5 × 1·0 mm. Lacertid hosts: *Podarcis muralis* and *Lacerta viridis* (Europe).

Cercolecithos arrectus (Molin 1859)

(51) 52. Coils of the uterus confused. Genital orifice slightly displaced to left. Cirrus-sac not extending behind ovary. Vitellaria separated by a lacuna behind testes. Spinous. 5·3 × 1·8 mm. Amphibian host: *Rana esculenta*.

(? **Lecithopyge**) **hystrix** (Molin 1861)

(2) 53. Vitellaria extending both in front of the ventral sucker and behind the testes. Uterus well developed and more or less covering the intestinal coeca, not arranged in distinct tracts. Cirrus-sac and metraterm relatively short and scarcely parallel (compare with Auridistominae 2), orifices displaced to left. Gen. **Lecithopyge** mihi

(56) 54. Not narrowed behind level of ovary, posterior end blunt and rounded. Vitelline follicles and ova larger.

(56) 55. Vitellaria separated by a lacuna behind testes. ? Ova larger. Narrowed anteriorly. 5·3 × 1·8 mm. Amphibian host: *R. esculenta*. (? **L.**) **hystrix** (Molin 1861)

(55) 56. Vitellaria contiguous behind testes. Not narrowed anteriorly. Spinous. 4·5 × 1·25, ova 0·055 × 0·033 mm. Amphibian host: *Rana temporaria* (Europe).

L. rastellum cylindriforme mihi

(54) 57. Narrowed behind level of ovary, posterior end acuminate. Vitelline follicles and ova smaller.

(59) 58. Cirrus-sac at least twice as long as the width of the ventral sucker, sigmoid. Sexual orifices closer together and usually combined but may appear separated. Greatest width before middle of body. Spinous.

(1) In *Rana temporaria* (England): Suckers smaller, ratio 1·3. 3·48 × 0·93, ova 0·040 × 0·024 mm.

(2) In *Bufo calamitas* (England): Suckers larger, ratio 1·5. 2·90 × 0·64, ova 0·043 × 0·026 mm. **L. rastellum subulatum** mihi

(58) 59. Cirrus-sac hardly longer than the width of the ventral sucker. Female aperture distinctly separated from the male and more to the left of the sucker. Greatest width at middle of body. Spinous. 4·0 × 1·0, ova 0·036 × 0·02 mm. Amphibian host: *Rana temporaria* (Sweden). **L. rastellum rastellum** (Olsson 1875)

(1) 60. Genital aperture widely distant from the ventral sucker.

(72) 61. Genital aperture widely displaced from the median line.

(65) 62. Coils of the uterus normally confined to the intercoecal space, and not pressed down over the testes. Prepharynx present. Genital aperture on left margin of body. Testes in tandem. Gen. **Protenes**

(64) 63. Vitellaria situated entirely behind the ovary. Uterine tracts distinct. Oesophagus short. Spinous. 2·013 × 0·275, ova 0·051 × 0·023 mm. Chelonian host: *Chrysemys marginata* (N. America). **P. leptus** Baker and Covey 1911

(63) 64. Vitellaria extending in front of both ovary and ventral sucker. Uterine tracts mingled. Oesophagus long. 3·15 × 0·45, ova 0·042 × 0·021 mm. Chelonian host: *Chrysemys picta* (N. America). **P. angustus** (Stafford 1905)

(62) 65. Uterus well developed, extending over the intestinal coeca and sometimes the testes also.

(69) 66. Genital aperture on the ventral surface, not the margin, but well to the left of the median line. Testes in tandem or oblique. Gen. **Telorchis**

(68) 67. Cirrus-sac extending behind the ventral sucker and reaching the ovary. Testes nearly in tandem. Spinous. 6·0 × 1·25 mm., ova 0·023 × 0·014 mm. Ophidian hosts: *Eunectes scytale, Hydroscopus plumbeus, Coluber flaviventris* and *Cloelia fasciata* (S. America). **T. clavus** (Diesing 1855)

(67) 68. Cirrus-sac wholly before the ventral sucker, shorter. Testes more or less oblique. 5·0 × 2·0 mm. Ophidian host: *Eunectes* sp. (? S. America).

T. anacondae (MacCallum 1918)

(66) 69. Genital aperture on the margin of the body, usually the right but frequently on the left, and well advanced anteriorly. Testes oblique or horizontal.

Gen. **Dolichopera**

(71) 70. Cirrus-sac large, reaching the middle of the ventral sucker. Testes but little overlapped by the uterus, the greater part of which lies behind the ventral sucker. Vitellaria more extensive. Testes oblique. Prepharynx absent. Oesophagus very short or absent. Spinous. 3·0 × 1·3, ova 0·030 × 0·0185 mm. Ophidian hosts: *Denisonia superba* and *Notechis scutatus* (Australia). **D. macalpini** Nicoll 1918

(70) 71. Cirrus-sac shorter, not reaching the ventral sucker. Testes nearly horizontal, and more extensively overlapped by the uterus which lies chiefly in front of the ventral sucker with only a small portion between the ovary and the testes. Vitellaria less extensive. Genital aperture on the right margin. Prepharynx absent, oesophagus present. Spinous. 2·4 × 0·7, ova 0·039 × 0·022 mm. Ophidian host: *Python variegatus* (Australia). **D. parvulus** Nicoll 1914

(61) 72. Genital aperture median or nearly so, closer to the oral than to the ventral sucker. (Compare with Auridistominae 4–8.)

(80) 73. Uterus less developed, normally confined to the intercoecal space. Genital aperture behind the bifurcation of the intestine. Testes nearly in tandem.

Gen. **Dolichosaccus**

(75) 74. Vitellaria hardly extending so far as the genital aperture in front. Ovary on right. Prepharynx present. Oral sucker much larger than the ventral. Spinous. 2·98 × 0·91, ova 0·037 × 0·022 mm. Amphibian hosts: *Limnodynastes peronii* and *Hyla aurea* (Australia). (Compare with Auridistominae 6 and 8.)

D. trypherus Johnstone 1912

(74) 75. Vitellaria attaining up to or in front of the genital aperture. (Compare with Auridistominae 7.)

(79) 76. Vitellaria not attaining the level of the pharynx in front. Ovary on right.

[(78) 77. Ventral sucker largest. Prepharynx present. Not spinous.

See **B. juvenilis** Nicoll 1918]

(77) 78. Suckers almost equal. Prepharynx ? not present. Spinous. 2·2 × 0·65, ova 0·036 × 0·021 mm. (Compare with Auridistominae 8.) Amphibian host: *Hyla freycincti* (Australia). **D. diamesus** Johnstone 1912

(76) 79. Vitellaria attaining the level of the pharynx in front. Ovary median. Prepharynx present. Oral sucker largest. Spinous. 4·5 × 1·1, ova 0·042 mm. long. Amphibian hosts: *Limnodynastes dorsalis* and *Hyla coerulea* (Australia).

D. ischyrus Johnstone 1912

(73) 80. Uterus well developed, covering the intestinal coeca and sometimes overlapping the testes. Genital aperture a little further forward, about the level of the pharynx. Testes diagonal. Oesophagus very short. Gen. **Brachysaccus**

(82) 81. Vitelline range interrupted by the uterus. Ovary median. Cirrus-sac reaching nearly to posterior margin of ventral sucker. Oral sucker distinctly larger than the ventral. Prepharynx ? not present. Spinous. 1·47 × 0·57, ova 0·034 × 0·019 mm. Amphibian host: *Hyla coerulea* (Australia).

B. symmetrus Johnstone 1912

(81) 82. Vitelline range continuous. Ovary on the right. Oral sucker not larger than ventral. Cirrus-sac scarcely reaching the ventral sucker.

(84) 83. Suckers equal in size. ? Uterus more extensive, separating the ovary from the cirrus-sac in front and the testes behind. Prepharynx present. Spinous. 3·3 × 1·2, ova 0·034 × 0·019 mm. Amphibian hosts: *Hyla aurea* and *Limnodynastes peronii* (Australia). **B. anartius** Johnstone 1912

(83) 84. Ventral sucker larger than oral. ? Uterus less extensive so that cirrus-sac, ovary, and testes lie closer together. Prepharynx present. Not spinous. 1·4 × 0·6, ova

0·045 × 0·027 mm. (only young specimens known). Amphibian host: *Chiroleptes brevipalmatus* (Australia). **B. juvenilis** Nicoll 1918

VI. A KEY FOR DETERMINING THE SPECIES OF AURIDISTOMINAE.

(4) 1. Oesophagus long. Cirrus-sac short. Genital orifice just before ventral sucker. Greater part of uterus lying in front of ovary which lies near testes.

(3) 2. With lateral and median diverticula from the oesophagus as well as the two regular intestinal limbs. Vitellaria extending in advance of the ventral sucker, as far as the bifurcation of the intestine. Testes in tandem. **Calycodes** Looss 1902
Spinous. Ventral sucker largest. 9·75 × 1·25, ova 0·063 × 0·042 mm. Numerous. Host: *Thalassochelys corticata* (marine). **C. anthos** (Braun 1901)

(2) 3. Oesophagus simple, without diverticula. Vitellaria not extending anterior to ventral sucker. Testes in tandem. Compare with Telorchiinae (3) 50.
Rhytidodes Looss 1902
Smooth. Suckers nearly equal. 20·0 × 2·5, ova 0·067 × 0·038 mm. Numerous. Hosts: *Thalassochelys corticata*, *Chelone mydas*, *Podocnemis expansa*, *Halichelys atra* and *Emys lutraria* (marine). **R. gelatinosus** (Rudolphi 1819)

(1) 4. Oesophagus and prepharynx short. Cirrus-sac long. Genital orifice well in advance of ventral sucker. Greater part of uterus lying behind ovary which lies near the ventral sucker. Compare with Telorchiinae 72.

(8) 5. Vitellaria extending far in advance of the testes. Genital orifice close to bifurcation of intestine. Uterus disposed in ascending and descending tracts.
Pterygomaschalos Stunkard 1924

(7) 6. Vitellaria not extending anterior to ovary. Oral sucker largest. 3·0 × 0·6, ova 0·050 × 0·030 mm., few. Host: *Chelydra serpentina* (N. America). Compare with Telorchiinae 74. **P. chelydrae** (Macallum 1921) non Stafford 1901

(6) 7. Vitellaria reaching almost to the bifurcation of the intestine. Spinous. Oral sucker largest. 2·5 × 0·26, ova 0·028 × 0·017 mm. Host: *Chelydra serpentina* (N. America). Compare with Telorchiinae 75. **P. attenuatus** Stunkard 1924

(5) 8. Vitellaria extending but little anterior to the testes. Genital orifice midway between bifurcation of the intestine and the ventral sucker. Uterus not clearly disposed in ascending and descending tracts. Compare with Telorchiinae 78.
Auridistomum Stafford 1905
Spinous. Testes oblique. Oral sucker largest. 6·0 × 0·74, ova 0·031 × 0·017 mm. Host: *Chelydra serpentina* (N. America). **A. chelydrae** (Stafford 1901)

I have much pleasure in acknowledging the kind advice of Dr H. A. Baylis, and the assistance afforded by a scholarship at Trinity College, Cambridge, a Trotman exhibition of the Worshipful Company of Haberdashers, and a grant from the Board of Industrial and Scientific Research, at the time when this work was in progress.

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EXPLANATION OF PLATES XX AND XXI.

PLATE XX.

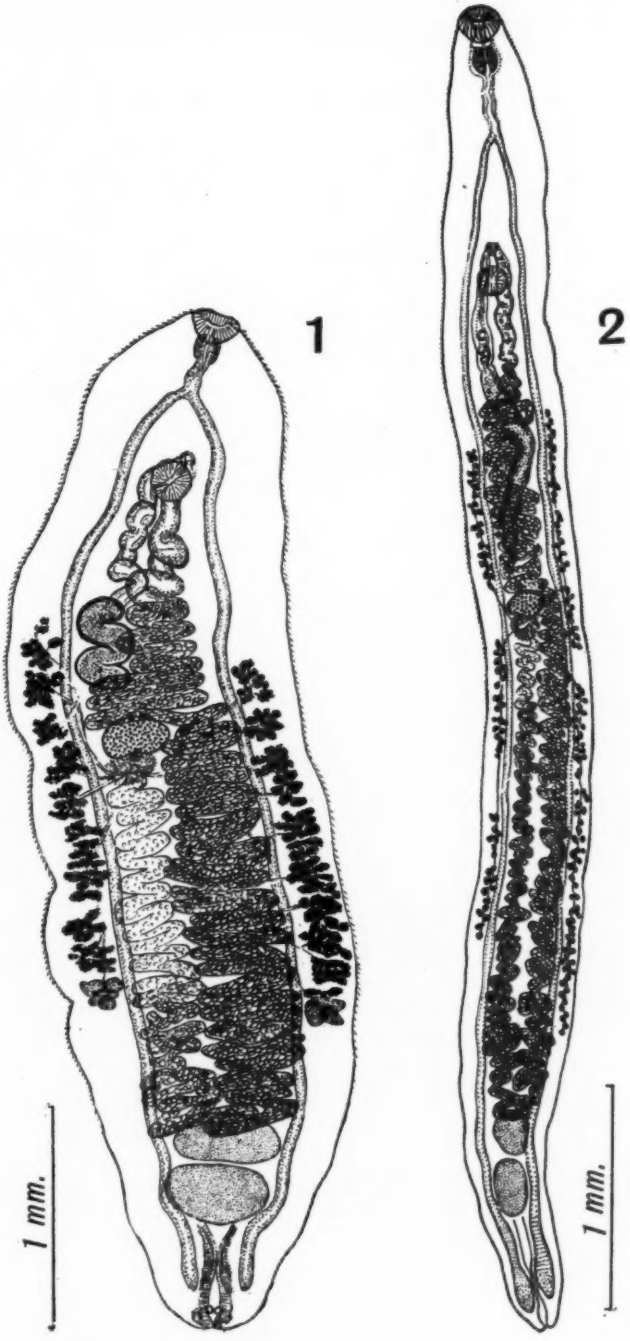
Fig. 1. *Cercorchis necturi* n. sp.
Fig. 2. *Cercorchis ercolanii* (Monticelli 1893).

PLATE XXI.

Fig. 3. "*Monostomum hystrix*" (from Molin's figure and description).
Fig. 4. *Lecithopyge rastellum cylindriforme* subsp. nov.
Fig. 5. *Lecithopyge rastellum subulatum* subsp. nov.
Fig. 6. *Lecithopyge rastellum rastellum* (from Olsson's figures).

Figs. 1, 2, 4 and 5 (all semi-diagrammatic) were drawn with the aid of the camera lucida. (M.P. del.)
All figures are drawn from the ventral surface.

(*MS. received for publication* 11. VI. 1928.—Ed.)



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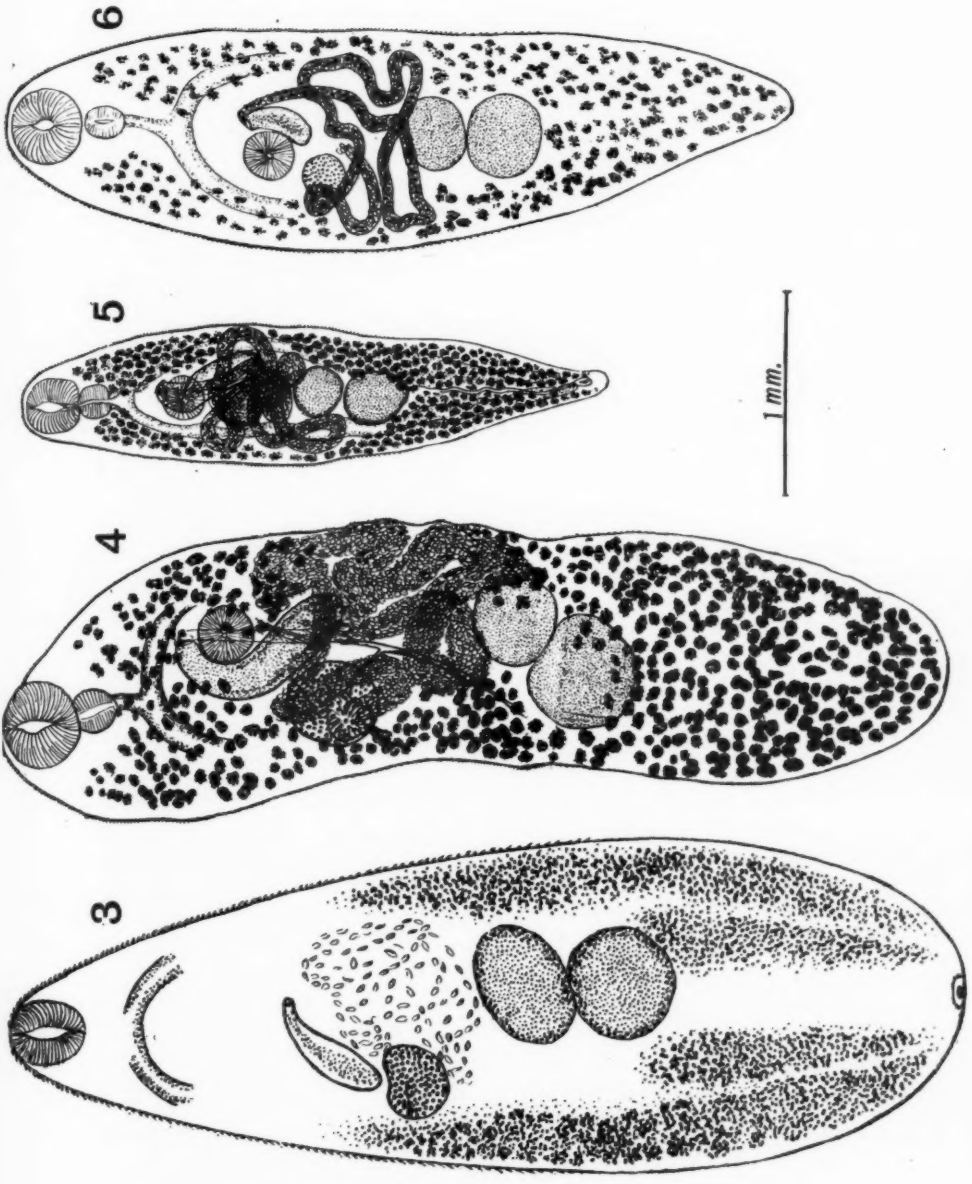

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The Cambridge University Press has appointed the University of Chicago Press agent for the sale of *Parasitology* in the United States of America and has authorised the following prices: Subscription $10.75 net per volume; single numbers $3.75 net each, double numbers $7.50 net each.

PRINTED IN GREAT BRITAIN BY W. LEWIS, M.A., AT THE CAMBRIDGE UNIVERSITY PRESS